POWER PLANT ENGINEERING

Established Over 28 Years

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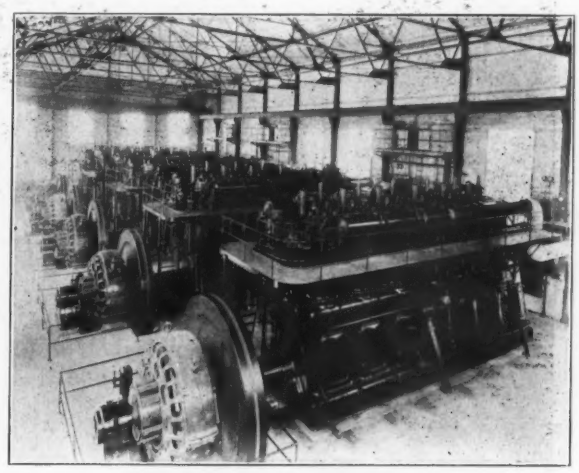

25,000 Hp. Oil Engines?

NOT MANY years ago, steam turbines of 5000 kw. were considered problematical. Today 100,000 kw. units are in the offing. The oil engine is now about where the turbine was; but the Prime Movers Committee of the N. E. L. A. reports one manufacturer as willing to build a 25,000 hp. engine.

Since oil engine development is of timely interest to both designers and operators we wish to call attention to a series of articles on the solid injection engine by H. F. Birnie and R. C. Baumann, which begin in this issue. The development of this type is newer than the air-injection engine, which has been covered in previous articles, and many of the design features are yet in the process of evolution.

RUNNING a 35,000 v. circuit through the inside of a smoke stack would not, under ordinary circumstances, be considered good electrical engineering. It would play havoc with the insulators; furthermore there would be no sense in it. Under certain conditions, however, this practice appears to be good boiler plant engineering and the arrangement, it is expected, will do much to eliminate the discharge of flue dust from the stack. Systems of electrostatic precipitation have been used for a number of years in the smelter and cement industries but it was not until recently that an application of the process was made in a power plant. The article on this subject appearing in this issue contains further information on the process.

Serv-Ice Co. Builds New Electrically Driven Raw Water Ice Plant in Columbus, Ind.

UNUSUALLY CLEAR PRODUCT IS OBTAINED BY THE USE OF LIME AND SODA SOFTENING AND HIGH PRESSURE AGITATION

TO MEET an urgent demand for ice in Columbus, Ind., the recently organized Serv-Ice & Coal Co. has just completed the erection of a new 30-T. compression system ice plant to supply the local retail trade. The plant operates on the raw water system and is electrically driven throughout. Inasmuch as the trade is largely with private consumers for household purposes, clear ice is demanded and consequently great pains have been taken to insure a perfectly transparent product. This is secured by the use of a carefully worked out cold-water softening system and high-pressure air agitation for the cans.

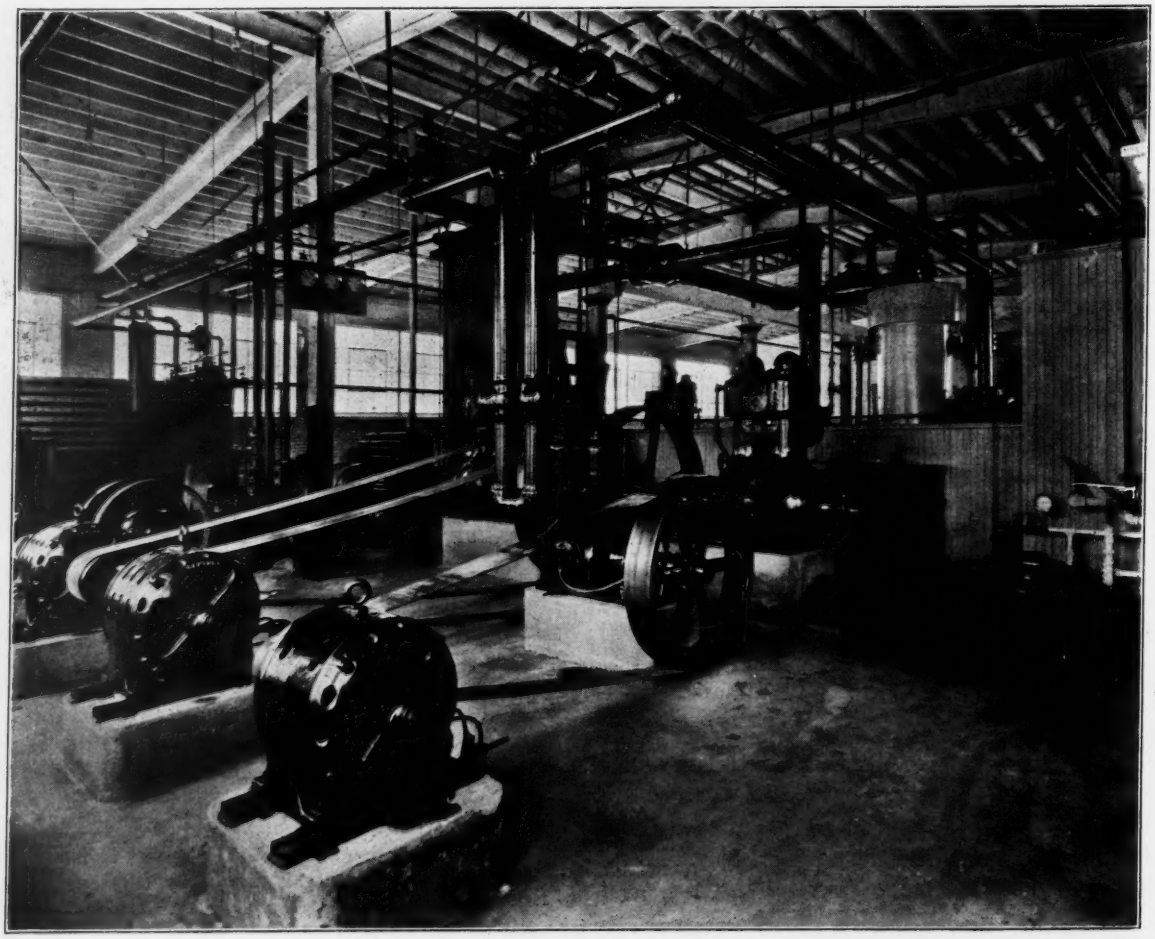

FIG. 1. TWO 15-T. COMPRESSORS CARRY THE LOAD WITH AN 8-T. STANDBY UNIT

Under normal summer operating conditions the capacity of the plant amounts to 30 T. per day, but this may be increased somewhat to help meet peak loads by cutting in the standby compressor. This, of course, means carrying a lower brine temperature and a lower suction pressure which entails a lower compression efficiency. As a consequence, the third compressor is not used except when it is absolutely necessary to boost capacity. Plans for this plant were completed and the building started Oct. 1 of last year. It was finished and put in operation for a test Feb. 15. On March 20 they took on the load and started building up the 2000-T. storage reserve. This storage is now full, as is also the small service storage and the plant is operating practically at capacity to meet the current demand.

FREEZING TANK DESIGNED FOR 58-HR. FREEZING TIME

Ice is made in 300-lb. cans, of which there are 484, arranged 22 across and 22 along the length of the brine tank which has overall dimensions of 27 ft. 1 in. by 50 ft. 3 in. The ice cans are 45 by 22 by 11 in. and the brine is maintained about 42 in. deep, i. e., a little more than 3 in. below the top of the cans. At a capacity of 30 T. a day, there are $30 \times 2000 \div 300 = 200$ cans pulled every 24 hr. or on the average two cans every 15 min. This rate of pulling gives a freezing time of $24 \times 484 \div 200 = 58$ hr.

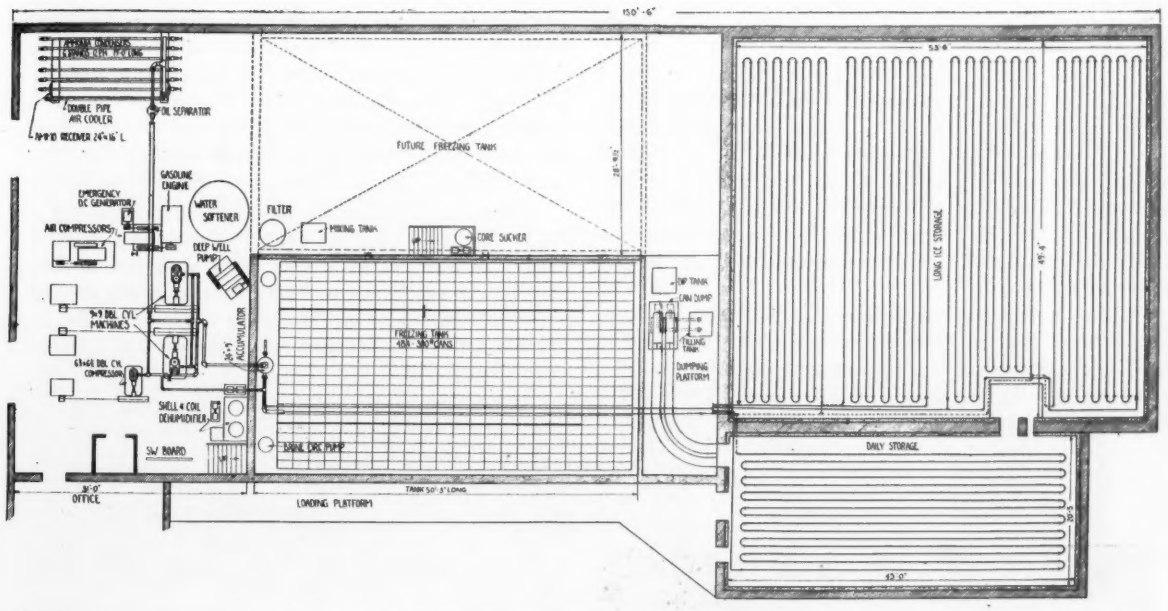

FIG. 2. ARRANGEMENT OF UNITS MAKES FOR CONVENIENCE IN OPERATION

approximately. The cans are pulled two at a time straight across a row, taking every alternate row in succession.

Spanning the width and running lengthwise of the tank is a crane used to lift the two cans from the tank and deposit them at the dipping tank at the north end of the platform. The cans are allowed to stand here for about a half hour to temper and are then doused in the dipping tank to thaw the cake loose from the can. They are then hoisted to the dumping rack and dumped, the ice sliding down two inclined runways into the service storage rooms. The cans are then filled with a measured supply of water from automatic measuring tanks overhead and are then replaced in the brine. Hoisting is done by a 2-hp. slip ring Euclid trolley motor hung on the I-beam crane but both trolley and crane are moved by hand.

When the cans are in place, air connections are made and the cake is allowed to freeze until the ice has attained a thickness of about 5 in. At this point the core, which by this time is a concentrated solution of lime water having a milky white appearance, is sucked out and replaced with fresh treated water. This is accomplished with the cans in place by means of a centrifugal core pump direct connected to a 1½-hp. General Electric motor, located at one side of the tank, and a double hose long enough to reach any can in the tank. The air tubes blow throughout the entire freeze.

To facilitate construction the brine tank is placed on a foundation approximately level with the compressor room flow. The tank itself is of fabricated sheet steel which rests on a 5-in. layer of cork insulation. Insulation for the sides is afforded by packed granulated cork 1-ft. thick. To provide for effective circulation of the brine a baffle is thrown across the tank about 3 ft. from the south end and from this, bulkheads, 5-cans distant from the side walls, extend to within three cans of the opposite end. Behind the cross bulkhead there are two propellor type agitation

FIG. 3. PLANT HAS A CAPACITY OF 30 T. ON A 58-HR. FREEZING TIME BASIS

pumps which are driven by direct connected 3-hp. Westinghouse motors operating at 870 r.p.m.

Ammonia coils, 10 pipes high, run the full length of the tank between every two rows of cans. The pipe is 2½ in. in diameter and there are 11 banks which gives a total cooling surface of approximately 3800 sq. ft. The plant operates on a pressure flooded system with a shell and coil accumulator partially submerged in the brine. The accumulator permits of operating the freezing tank flooded while the compressor receives only saturated or slightly superheated vapor.

Three York compressors are installed, two of these having an ice-making capacity of 30 T. each are ordinarily kept in service. Unit No. 3 is an 8-T. machine, which is employed as a standby to be used only in case of emergency or in place of one or both of the larger machines when the plant is running at less than capacity. The first two units are identical except that they run in opposite directions. They are 9 by 9-in. two-cylinder single acting ma-

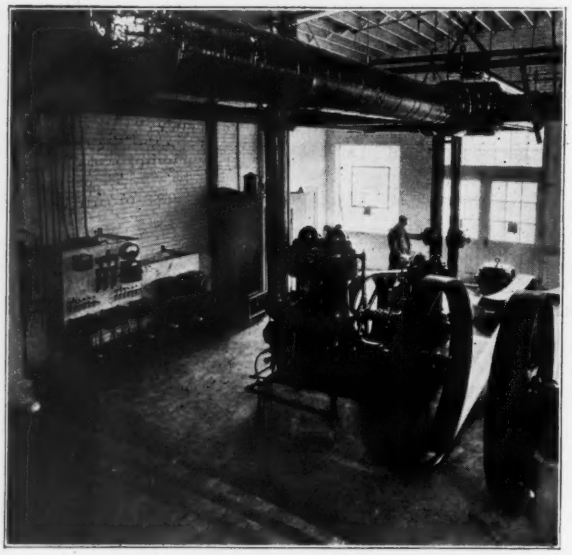

FIG. 4. ONE OF THE 15-T. COMPRESSORS AND THE 8-T. STANDBY MACHINE

chines and operate at 168 r.p.m. At this speed the volumetric displacement is approximately 111.5 cu. ft. per min. for each machine. Each is belt driven from a Century Electric Co. 40-hp., 3-phase 60-cycle 220-v. squirrel cage induction motor. The smaller unit is a 6½ by 6½-in. two-cylinder single-acting machine which is belt driven from a 20-hp. Century motor of the same general characteristics as the two larger motors. These machines are almost totally inclosed and are self oiling; they require but little attention from the operator beyong keeping the correct oil level in the sump and seeing that the stuffing boxes are not too tight or do not leak ammonia.

For ordinary summer operation the brine temperature is carried at about 15 deg. F. and the suction pressure on the compressor is about 25 lb. With cooling water at 58 deg. F. the discharge pressure can be kept at about 150 lb.

Double Pipe Ammonia Condenser Is Used

Ammonia is condensed in a battery of six banks of double-pipe counter-flow condensers located in the southwest corner of the compressor room. Each bank is 12 pipes high and 19-ft. long and is made up of 1¼-in. pipe inside and 2-in. pipe outside. Water flows in at the bottom in the inner pipe and out at the top. The total water cooling surface is approximately 600 sq. ft. and at normal rating the ammonia is condensed with a temperature rise through the condenser of about 15 deg., from about 60 to 75 deg. F.

From the condenser the liquid ammonia flows by gravity to the 24-in. diameter by 16-ft. welded receiver. Normally the liquid level in this drum is carried about half way up the gage glass. Under these conditions the reserve capacity is about 25 cu. ft. From the receiver the liquid ammonia flows under condenser pressure to the several expansion valves.

In addition to the brine coils, direct expansion is supplied to the two storage rooms. The so-called long storage is built to accommodate 2000 T. of ice. The room is 54 ft. 8 in. long by 49 ft. 4 in. wide and is insulated on all sides by 6 in. of cork blocks. The expansion piping is arranged

TABLE. CHEMICAL COMPOSITION OF RAW WATER USED FOR MAKING ICE

	Parts per Million
Incrusting Solids	
Calcium Carbonate	198.0
Calcium Sulphate	.....
Calcium Chloride	.....
Magnesium Carbonate	28.0
Magnesium Sulphate	40.0
Magnesium Chloride	....
Iron Oxide	0.7
Aluminum Oxide	2.5
Silica	8.0
Suspended Matter	5.0
Total	282.2
Non-Incrusting Solids	
Sodium Sulphate	7.0
Sodium Chloride	11.0
Sodium Carbonate	....
Total	18.0
Total Solids	300.2
Dissolved Gases	
Free Carbon Dioxide	7.0

in four double banks directly below the ceiling. Each bank is 45-ft. long and is made up of twenty-four 2½-in. pipes. The cooling surface is thus about 1600 sq. ft. The service storage contains a single coil, also suspended under the ceiling, 16 pipes wide and 40-ft long, having a total surface of about 480 sq. ft.

Ordinarily, the temperature in the service storage is kept at about 22 deg. and that in the long storage at about 20 deg. F. The amount of liquid entering these coils is controlled by three expansion valves located at one end of the freezing tank where they are easily accessible to the operator.

Raw water supply is taken directly from the city mains. This water normally contains about 18 gr. per gal. of scale forming material and consequently has to be treated in order to make it satisfactory for making ice. A typical report of the water analysis indicates a suspended matter content of five parts per million and total dissolved solids amounting to 295.2 parts per million. The chemical composition is as given in the accompanying table.

Incrusting solids are eliminated by treatment with lime and soda ash in an International Filter Co. water softening system having a capacity of 550 gal. per hr. Essentially, the apparatus consists of a vertical wood-stave tank, 6-ft. diameter by 14-ft. high, at the center of which there is an 18-in. diameter down-take. Beside this is mounted on the compressor room floor a 3-ft. diameter by 5-ft. high sand and gravel filter and a chemical mixer which feeds a given quantity of chemical to the raw water. Lime and soda ash is added in the desired proportions to the mixing tank where it is dissolved in a small quantity of water to give a super-saturated solution. A series of paddle wheels rotating about a horizontal axis serves to keep the contents in a state of constant agitation to insure a uniform mixture. The end set of paddles is provided with a cup on each blade which dips into the mixture at each revolution and brings up a cup full. At the top a definite amount spills into a trough from which it is pumped to the entrance of the down pipe where it mixes with the incoming raw water. This raw water is admitted in such a way as to insure intimate mixture with the chemical. Reaction takes place almost immediately and the precipitate settles to the bottom where it is flushed out at intervals.

This treated water emerges from the bottom of the down pipe into the tank proper where it rises slowly, allowing plenty of time for the completion of the reaction. A small quantity of alum is added to the water to coagulate the precipitate into a flocculent mass to hasten the precipitation. From the settling tank the water is passed through the filter where the last trace of precipitate is removed. From the filter the treated water passes directly to the filling tanks where the correct quantity is measured out to fill the ice cans.

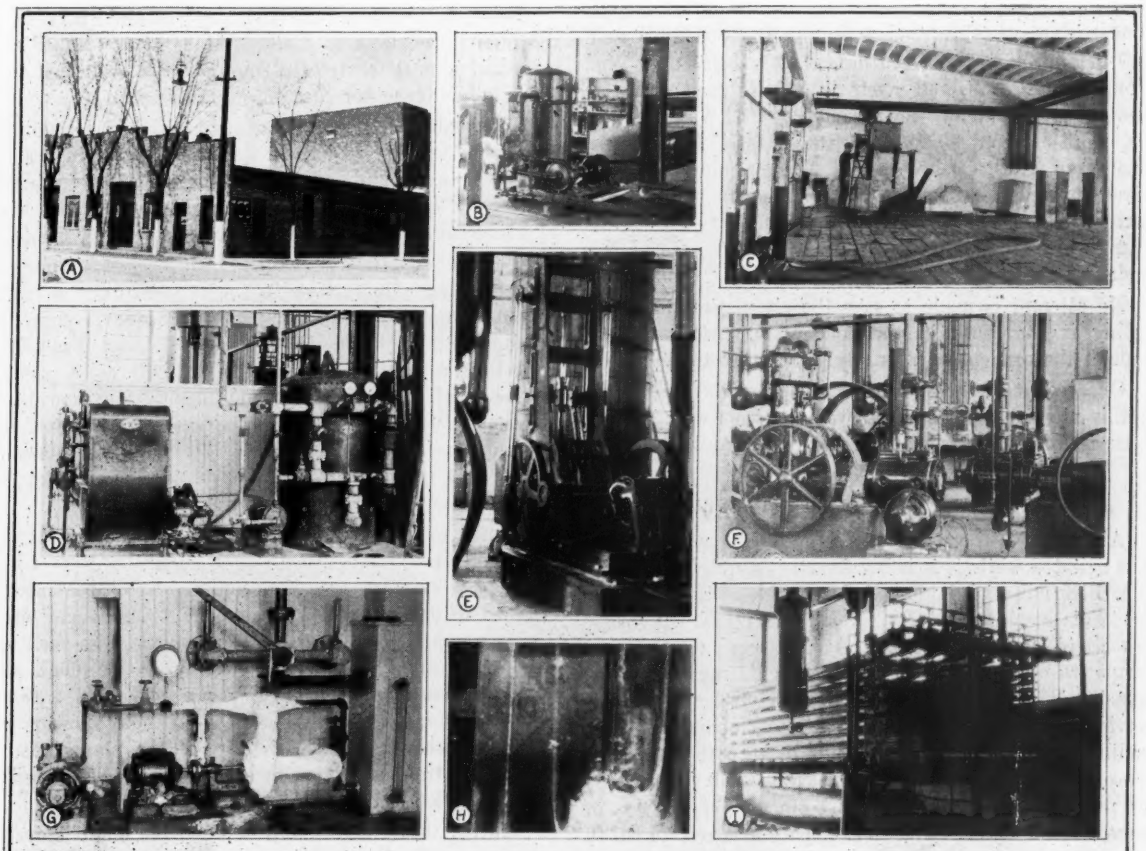

FIG. 5. GLIMPSES OF THE SERV-ICE PLANT

A. Serv-Ice Co. plant showing 2000-T. storage house. B. Cores are pumped with the centrifugal pump driven by a 1½-hp. motor. C. Dumping rack at one end of the freezing tank. Notice the cans being left to temper. D. Chemical mixing tank and sand and gravel filter. E. Motor driven deep well plunger pump delivers 110 g.p.m. F. Duplicate air compressors. One is driven by a gasoline engine. Notice the small d.c. generator. G. Brine circulating pump. H. Product is unusually clear. I. Double pipe ammonia condenser and air cooler.

Two Sources of Circulating Water Are Used

During the winter months, circulating water for the ammonia condensers is taken from the city mains but during the summer it is pumped from a well. The impor-

tant characteristic of cooling water is, of course, its temperature. During the winter, the temperature of the city water is low enough to make its use as a cooling medium economical. As its temperature increases with the approach of summer, more and more has to be used to effect the same cooling and the cost gradually is increased until a temperature is reached where it is more economical to use well water. This has been roughly determined at about 58 deg. F., which is the average temperature of the well. It is likely, however, that a more careful analysis would indicate that a bigger saving could be effected by changing over from city to well supply at a somewhat lower city water temperature.

Well water is taken from a comparatively shallow well sunk in the compressor room immediately adjacent to No. 1 compressor. The well itself is 310-ft. deep and the working barrel extends down some 200 ft. Water stands at a depth of about 40 ft. below the surface. Pumping is done by an A. D. Cook deep-well plunger pump which is driven through a system of reduction gears by a 15-hp. Century motor. The capacity of this unit is about 110 g.p.m. which at 58 deg. is sufficient to take care of the condenser needs at a plant capacity of 36 T.

No attempt is made to save the circulating water by cooling it for reuse in the condensers. After passing through the condensers it is discharged directly to waste.

On account of the extreme hardness of the well water in this vicinity it cannot be used for ice making. City water is used for this purpose the year round.

High Pressure Air Is Used for Agitation

Air used for the purpose of keeping the water in the cans agitated while it is being frozen is applied by a 9 by 6-in. Pennsylvania single-cylinder double-acting compressor. This machine is belt driven from a 15-hp. Century motor and runs at 290 r.p.m. At this speed the unit has a capacity of about 130 cu. ft. of free air per min. This capacity is, however, not needed. The discharge line is provided with a pressure governor which operates an unloading device. This governor acts to keep the discharge pressure between the limits of 28 and 32 lb. Ordinarily the pump is unloaded for about 7 out of every 17 sec. of operation, indicating an actual capacity of about 75 cu. ft. per min.

From the compressor the air passes through an oil separator, thence to an after cooler or dehumidifier where the temperature is reduced to about 78 deg. and where excess moisture is precipitated out. This cooler is a double pipe apparatus built much like the ammonia condensers beside which it is located. The two pipes are respectively 2 in. and 3 in. in diameter. The single bank is 18 ft. long by 8 pipes high and contains approximately 90 sq. ft. of cooling surface.

Air leaving the cooler at a temperature of 78 deg., a relative humidity of 100 per cent and a pressure of from 28 to 32 lb., is piped to a shell and coil dehumidifier located at the compressor end of the ice-making tank. Here it is further cooled by brine circulation to about 26 deg. F. During this cooling the capacity of the air for holding moisture is still further reduced and consequently more moisture is precipitated out. This excess accumulates as frost on the brine coils. The air, saturated now at 26 deg., passes to a reducing valve where the pressure is reduced to from 15 to 15.5 lb., depending on the pressure on the high pressure side. At this pressure it enters a header running lengthwise of the ice tank and is distributed to the individual air pipes.

Owing to the rapid accumulation of frost on the brine coils in the dehumidifier and the consequent reduction in heat transmission efficiency, this apparatus is installed in duplicate, the air flow to the two sections being controlled by a quarter-turn three-way cock. The air flows through one shell for about an hour at a time—then the flow is diverted to the other shell while the first is allowed to defrost itself.

Brine is circulated through the dehumidifiers from the main brine tank at a temperature of 15 deg. F., by means of a small centrifugal pump direct connected to a 1-hp. induction motor running at 1700 r.p.m.

This elaborate means is taken to cool and dehumidify the air to prevent any accumulation of water in the air pipes where it would freeze and shut off the air for agitation. Such an occurrence would result in the production of white ice and is, of course, to be avoided if possible.

To insure continuity of the air supply for this purpose in case of an interruption in the power supply a motor driven compressor is installed. This standby compressor is a duplicate of the one in regular service, but it is driven by belt from a four-cylinder 4 by 5-in. Hercules gasoline engine which at full load operates at 850 r.p.m. and drives the compressor at 300 r.p.m. In case of failure of the current supply, this unit can be started on a moment's notice and there is thus but little opportunity for the formation of white ice.

Belted to the flywheel of the standby compressor is a small d.c. generator which, at a speed of 1900 r.p.m. develops 3 kw. at 115 v. The output of this generator is utilized to operate a d.c. motor driven centrifugal circulating pump which is held as a standby for the shell and coil dehumidifier. All the apparatus in an ice plant, with the exception of the air system, can withstand a forced shut-down for a short period of time without showing any serious consequences but this part of the plant must be kept in continuous service, or a day's output of unmarketable white ice is likely to result.

During the summer months, when the plant is operating at capacity, the daily water consumption of the plant amounts to about 140,000 gal., exclusive of that used for can filling, which amounts to a little more than 7000 gal. The power consumption runs up to about 1300 kw. hr. per day, which corresponds to an average current consumption of 245 amp. at 220 v.

This plant was designed by the owner, C. D. Cook and Westerlin & Campbell of Chicago were the general contractors. To both, we acknowledge indebtedness for the courtesy and co-operation extended in the preparation of this article.

Tubes in economizers installed in connection with oil fired boilers take on a thin, hard, black, glossy coating on their outer surfaces; this coating, which in thickness is equal to the clearance between the tube and the scraper, should be removed periodically as it is a very effective heat insulator and cuts down the efficiency of the economizer very materially.

Prime Movers and Their Lubrication

SELECTION OF LUBRICANTS ADAPTED TO THE SERVICE INTENDED AND THE SYSTEM OF LUBRICATION, WILL INSURE CONTINUED PRODUCTION

STEAM POWER plant lubrication is of interest to the producer from the viewpoint of reducing operating expense and friction losses. The viewpoint from which the consumer is most concerned is that of continued service.

Lubrication of reciprocating engines can be broadly classified as internal and external, or in other words, as applying to steam cylinders and valve chests and to bearings, pins and guides. Steam cylinder lubrication must

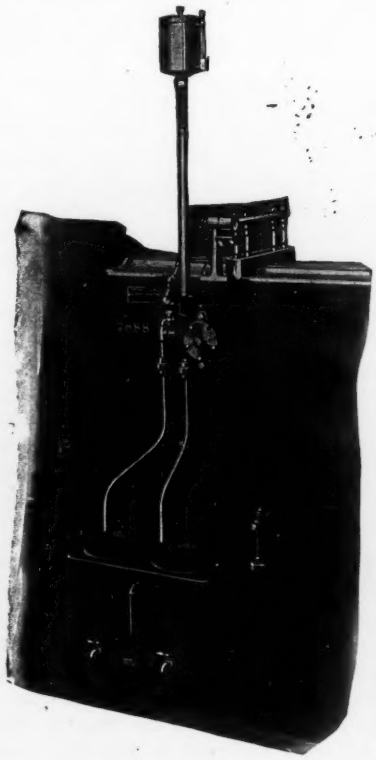

FIG. 1. AUTOMATIC LUBRICATION SYSTEM APPLIED TO THE BEARINGS OF A SKINNER ENGINE

be studied in conjunction with steam pressure, temperature, moisture conditions, engine design and construction and operating speeds. We can usually attain best results by regarding the above from the viewpoints of: (1) What the oil must lubricate, (2) How it must be applied, (3) The operating conditions it must meet, (4) How to select an oil best suited to these conditions and (5) How to determine whether lubrication is correct.

WHAT THE OIL MUST LUBRICATE

In developing what the oil must lubricate, we have primarily to deal with engine design and construction. The function of a steam cylinder oil is to lubricate every sliding surface which is either in direct contact with the steam, or subject to its pressure and temperature. Therefore valves, valve rods, valve seats, cylinder walls, pistons and piston rods are involved. These parts are not always subject to the same pressure and temperature conditions, yet the one oil must serve throughout and therefore be sufficiently flexible in operation to produce efficient lubrication wherever necessary.

Steam valve design is the governing factor in cylinder lubrication. There are, broadly, four types of such valves, i.e. the slide or D-valve, the piston valve, the Corliss and the poppet valve. Of all, the common slide valve is the most difficult to lubricate, due to inequalities of pressure and the consequent "wiping" action it exerts upon the lubricated valve seat. With the piston valve the steam pressure is balanced and as a result there is less tendency for the oil to be squeezed or wiped from the valve seat. The Corliss valve is a slide valve to the extent that it is subject to a sliding action on its curved seat similar to the D-valve. The chief difficulty with a Corliss valve is to maintain a suitable film of lubricant at the end of the valve, therefore individual feeders for the lubricant are usually installed at such points.

Poppet valves, while reciprocating in action, are not subject to sliding on the valve seat. As a result lubrication at this point is relatively unnecessary. Valves of this type are also balanced as to steam pressure, therefore they are capable of operation under higher pressures the same as piston valves. Poppet valves require lubrication of the stems only. Valve, piston and tail-rods require quite as

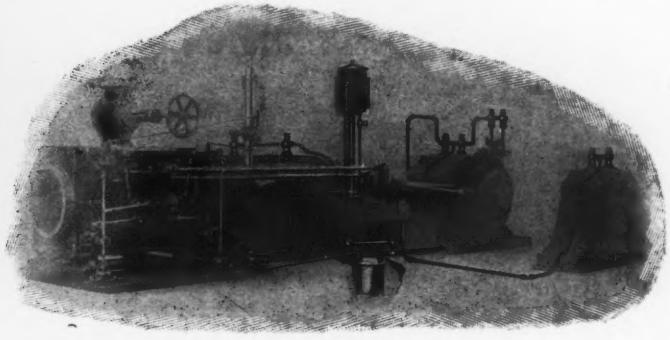

FIG. 2. CORLISS ENGINE EQUIPPED WITH AN INDIVIDUAL OILING SYSTEM AS MADE BY S. F. BOWSER & CO.

efficient lubrication as valve seats and cylinder walls if they are to operate effectively. In general, valves, pistons and tail-rods will receive sufficient lubrication from the oil in the steam, however, it is customary either to install auxiliary sight feed oil cups or make some other provision for oiling the rods externally at regular intervals.

METHOD OF APPLYING THE LUBRICANT

Cylinders are lubricated by either one of two methods: (1) Where the oil is applied directly to each of the separate wearing surfaces, and (2) Where the oil is fed into the steam line between the throttle valve and the steam chest, the steam serving to atomize it and carry it to all moving parts within the valve chest and cylinder.

Direct application of steam cylinder oils by means of individual oilers installed on the valve chest and cylinder is the more crude and uncertain of the two methods. It is perfectly evident that such a method of lubrication, while probably not objectionable in the case of a single-

cylinder engine, would be decidedly cumbersome and unreliable if applied to a multiple cylinder unit.

For this reason steam cylinder lubrication by means of injecting oil into the steam line, using a hydrostatic or mechanical force feed lubricator; is regarded as far more dependable and conducive to increased efficiency. The fact that the steam reaches practically all of the surfaces requiring lubrication in its passage through the engine insures the transmission of the particles of oil which it carries, to these parts; however, sufficient oil must be fed to the steam line and the point of introduction of the lubricant must be located at a suitable distance beyond the throttle valve and the steam chest to enable the steam completely to exercise its atomizing effect.

If the point of introduction is located too close to the throttle valve or cylinder, complete atomization may not take place; if too far away there will be a possibility of the oil particles being thrown to the walls of the steam line,

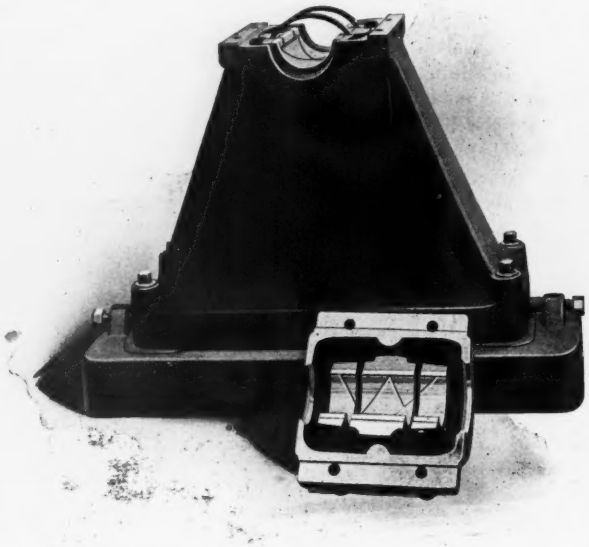

FIG. 3. OUTBOARD BEARING OF A RIDGWAY UNIFLOW ENGINE

from whence a flow of liquid lubricant will occur to the valve chest.

Hydrostatic lubricators embody the principle of forcing the oil, drop by drop, into the system by means of a head of water which is maintained by condensing of the steam. A hydrostatic installation cannot be depended upon to be absolutely positive due to the more or less errratic nature of the conditions to which it is subject. For example, a change in temperature will affect the viscosity of the oil, the size of the globules fed and consequently the regularity of the flow. In addition, the flow of oil will be independent of the engine speed, hence the working parts of the latter will seldom receive exactly the correct amount of oil to meet the conditions of operation.

Mechanical force feed lubricators more or less overcome certain of these objections by virtue of the fact that they are connected directly to some reciprocating part of the engine, consequently oil is fed into the system at a rate which varies directly with the speed. An efficient mechanical lubricator should feed the same amount of oil regardless of the temperature, viscosity or amount of oil in the reservoir. In general, while a device of this nature can be used with either a direct feed or an atomizing spoon, the spoon is more commonly used.

Operating Conditions that Must Be Met

While steam pressure alone has but little influence upon a cylinder oil, the temperature associated with the pressure, as well as the degree of superheat to which the steam may be subject, has a marked effect; therefore, where operating with high temperature saturated or superheated steam, a heavy bodied oil should be used.

From the viewpoint of the actual composition of a cylinder oil, the question of moisture in the steam is the most important factor involved. The presence of moisture in steam will usually result in a film of straight mineral lubricating oil being rapidly washed off from the cylinder walls and other surfaces with which the steam comes in contact; therefore, to secure proper lubrication under wet steam conditions, it is necessary either to increase the rate of flow of the straight mineral oil or else substitute an oil which contains a certain percentage of fatty compound such as lard oil, degras or tallow. The practice of using a straight mineral oil to lubricate wet steam is customary only where the presence of a fatty oil in the exhaust steam is objectionable.

Where a compounded oil is used, an emulsion is developed by the moisture in the steam reacting with the fatty component. The lubricating film thus has a greater affinity for the cylinder walls and other wearing surfaces and becomes highly resistant to the washing action of the water in the steam. Naturally, the greater the percentage of moisture in the steam the higher should be the fatty compound content of the lubricant; in general, the compound should not exceed 10 per cent.

Determination of Correct Lubrication

In general, the real test of a cylinder oil should be the condition of the wearing surfaces upon which it is used. Any test should, therefore, cover a period of several weeks. Then the engine should be shut down, the cylinder head and valve chest cover removed and the interior examined. If, upon immediate inspection, the wearing surfaces show a film of lubricant sufficient to penetrate three or four thicknesses of cigarette paper with a brownish stain, they are sufficiently lubricated. If below this film they appear highly polished and of a color varying from bright iron-white to steel-blue, they have been properly lubricated.

When the surfaces are rough, dry, dull in appearance or rusty, lubrication has either been insufficient or the wrong grade of oil has been used. In addition, if the stain on the cigarette papers appears streaked, blackish or mottled, either the oil has been subject to carbonization or abnormal wear has taken place. Excessive lubrication, on the other hand, will be indicated by pools of oil lying in the bottom of the cylinder or in the counterbore.

Under operation the efficiency of lubrication can be roughly judged by: (1) The film of oil on the piston rod; (2) The amount of oil in the condensate; (3) The action of the valves. A suitable film on the piston rod (unless oil is fed directly to it), minute drops of oil and a milky appearance in the condensate, free action and little or no noise in valve operation, are indications that the oil is suitable, atomization complete and the rate of feeding correct.

Engine bearings, guides and pins are, in general, lubri-

cated by one of two methods, using either sight feed oil cups or grease cups; or some form of continuous lubrication.

Oil and grease cups involve intermittent lubrication. In general, they are simple in operation and if properly adjusted will feed the right amount of lubricant to afford sufficient lubrication with but little waste. Drop feed oil cups require a relatively heavy oil which should be selected for its ability to remain on the bearing surfaces for fairly indefinite periods. As a general rule, systems of this nature will require an oil of from 300 to 500 sec. Saybolt viscosity at 100 deg. F.

Continuous Lubrication

Continuous lubrication involves a directly opposite theory to intermittent lubrication inasmuch as the bearings are literally flooded with an excess of oil over that which is absolutely requisite for proper lubrication. The function of the oil is therefore to act not only as a lubricant but also as a cooling medium to carry off any frictional heat that may be developed in the bearing under operation.

Continuous oiling may be broadly grouped into two classifications, i.e. (1) Splash lubrication and (2) Force feed lubrication. Splash lubrication is adaptable to installations where the crankcase is completely enclosed and the entire system oil tight. In equipment lubricated by splash systems, a quick water and sediment separation is imperative. The viscosity of the oil in a splash system should, therefore, be as low as is consistent with requirements in order to insure rapid precipitation.

In a force feed system, the oil is forced into the bearings at pressures ranging from 5 to 15 lb. per sq. in. This impetus to the oil may be obtained either by making use of the action of gravity or employing oil pumps. Lubricants used in a force feed system have their requirements controlled to a large extent by operating and constructional conditions. When the system includes ample purifying and circulating capacities, the oil will be subject to comparatively light duty inasmuch as bearings are continually washed out and there is ample opportunity for dirt and water to precipitate. A pure mineral oil of from 150 to 200 sec. Saybolt at 100 deg. F. will usually be satisfactory for such service.

Selection of engine lubricants depends largely, as has been seen, upon the method of application. In general, however, there are certain definite requirements which the oil must possess, such as: (1) Sufficient body or viscosity to prevent metal to metal contact of the surfaces to which it is applied but not so heavy as to produce high internal friction, (2) An ability to flow readily when low service temperatures are involved, (3) A flash point sufficiently high to indicate that a reasonable factor of safety has been provided and that loss due to evaporation will be low, (4) Ability to stand up under continued service without any excessive tendency towards decomposition or gumming, (5) Ability to meet special service requirements such as quick water separation, low vaporization and emulsification, (6) Freedom from impurities or corrosive acids, etc., which might prove injurious to the system.

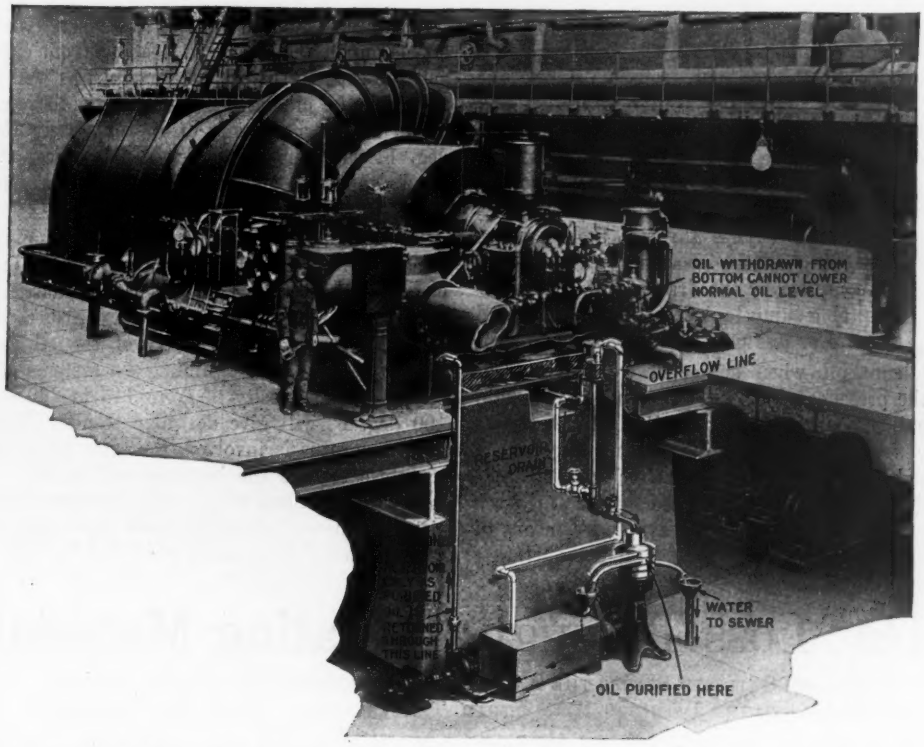

FIG. 4. APPLICATION OF A DE LAVAL OIL PURIFIER TO A LARGE TURBINE UNIT

Steam Turbine Lubrication

In general, the selection of turbine lubricants will be affected to a more or less extent by: (1) The rotational speed, (2) The size of the bearings and (3) The clearance space.

Speed of rotation is of importance in that it directly affects the amount of oil which will be drawn through the bearing clearance space. The size of the bearing enters

into the question in that it involves the weight and operating pressure to which the oil film in the clearance space is subjected. The clearance space is of importance in that it directly governs the maintenance of the oil film; that is, the greater the clearance and the more accurately this is expanded (or the bearing edges chamfered) at the point of entrance of the oil, the more readily will the revolving journal draw a suitable film of lubricant through the bearing. By expanding or chamfering the formation of a wedge of oil is made possible, the oil entering at the base or thicker part of this wedge and passing into the clearance at the point. In connection with the above, there are certain characteristics pertinent to the oil which must also be studied. Thus (a) the viscosity; (b) the cooling effect of the oil; (c) its evaporative tendency and (d) the tendency towards decomposition, emulsification, and sludge formation all are of distinct importance.

One of the chief functions of a turbine oil is to carry away to as great an extent as possible, the heat generated during operation. If this is not brought about, the viscosity and hence the supporting ability of the oil will drop to a certain extent, oftentimes even to such a degree as to render the oil incapable of keeping the metallic surfaces apart. So it is customary in larger installations to flood the bearing with oil under a certain uniform pressure. Part of this oil circulates through the clearance space, the excess serving as the coolant. The cycle of operation is made complete by the draining of this lubricant back into a suitable sump tank where it is cooled and then subjected to more or less purification before re-using.

Any petroleum oil when subjected to churning or agitation in the presence of air will evaporate to a certain extent, depending, naturally, upon its characteristics. Although the average turbine oiling system is generally tightly enclosed and built to operate as free from oil leakage as possible, a certain amount of the lighter and more volatile components in the oil will always find a means of escape from the system, especially under higher operating temperatures. As a result, the remaining oil will gradually tend to increase in viscosity.

However carefully refined a turbine oil may be, a certain amount of oxidation and decomposition will take place if it is subjected to abnormally high temperatures in the presence of air. Such reactions are indicated by a darkening in the color of the oil. From a lubricating viewpoint, however, this alone has yet to be proved a detrimental feature. As a result of this change in characteristics, gumming and emulsification will result, especially if water is present. The most important effect of this gradual decomposition and oxidation of turbine oils is the formation of sludges.

Turbine bearings may be either lubricated by ring or chain oilers or some form of self-contained force feed circulating system. As a general rule ring oilers, etc., are not adaptable to machines above 300 hp. in capacity. For ring and chain oil lubrication the viscosity of the oil will depend upon the extent of heating from external sources and the capacity of the oil reservoir, as well as the extent to which the oil may be cooled by radiation. Ordinarily an oil having a viscosity of approximately 150 sec. at 100 deg. F. will be suitable for such service. On the other hand, abnormal temperature conditions may sometimes require an oil of much greater body.

Force feed lubrication involves the supplying of a positive flow of oil to all bearings under a definite pressure and is used on practically all larger installations. Owing to the fact that the constant pressure insures comparatively flood lubrication the viscosity of the oil can usually be maintained within low limits. In systems of this type an oil having a viscosity of from 145 to 200 sec. Saybolt at 100 deg. F. will give desirable results. When reduction gear apparatus is involved, the same oil is generally used to lubricate both the bearings and gears.

These relations which exist between scientific lubrication and power plant problems have been gleaned from "Lubrication," a magazine published by The Texas Co.

Heat Loss Through Insulating Materials

Method Outlined Before the A.S.M.E. for Calculating Heat Loss Through Pipe Covering Used for High Steam Temperatures. By R. H. Heilman*

TENDENCIES IN steam power and industrial plants of various types to increase their steam temperature by means of superheat has caused the manufacturers of pipe and boiler coverings to renew their efforts to provide suitable insulations and specifications to keep pace with the increasing temperatures.

Some manufacturers are specifying the use of an inner covering next to the pipe which has a high resistance to the effects of heat, with an outer covering having not so high a resistance to the effects of heat but having a lower conductivity value. The inner covering should be applied in sufficient thickness to lower the temperature at the inner surface of the outer covering to a point where the physical structure of the covering will not be appreciably affected by the heat.

Use of the term "thermal conductivity" has been rather loose in the last few years by investigators and in engineering literature. This lack of correct definition has therefore caused considerable misrepresentation as to the true conductivity values of insulating materials reported by them. In fact, practically no reports are available in engineering literature which present the true conductivity values of pipe-covering materials tested so that they may be applied in determining the heat loss for conditions not exactly similar to the test conditions under which the constants were determined. The true meaning of the term thermal conductivity of a material is the number of heat units transferred by conduction per unit area, across unit thickness, per degree difference of temperature between the faces, the direction of heat flow being perpendicular to these faces.

In terms of the units generally used in power-plant practice this is equivalent to the heat transmitted in B.t.u. per hr. through 1 sq. ft. of material 1 in. thick and having 1 deg. F. temperature between its faces. It is practically impossible to realize a condition in engineering or laboratory practice where the temperature difference between two faces 1 in. apart is only one degree and the conductivity of an insulating material has therefore generally been

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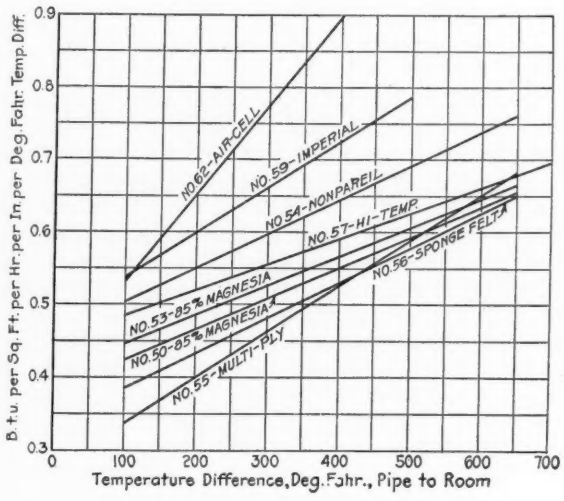
taken as the average conductivity value through the whole test section; the conductivity thus obtained being plotted against the temperature difference between the two surfaces or between the inner surface and the room temperature. Plotting average conductivity against temperature difference at the two surfaces for heat-insulating material may give, in some cases where single thicknesses are used, solutions sufficiently accurate for engineering purposes but where compound sections are employed and where different external surfaces exist as in coverings on various-diameter pipes—with a resulting change in the surface-emissivity factor—it is not safe to use the values obtained from conductivity curves plotted against temperature differences.

For example, the conductivity of heat-insulating materials increases as the temperature increases. The conductivity value of a given material whose faces are at 200 and 100 deg. F. must therefore be lower than the conductivity



CURVES OF THERMAL CONDUCTIVITY

for the same material having its faces at 700 and 600 deg. F. although the temperature difference is 100 deg. in each case.

In all the tests on commercial insulating coverings conducted by the author there was no covering tested whose conductivity did not obey a straight-line law. This fact reduces considerably the experimental work required to obtain true conductivity values for the insulating materials tested, as it is only necessary to measure the heat transmitted through the covering and the corresponding surface temperature.

Calculation of Heat Losses through Coverings

Theoretical calculation of heat losses through coverings on flat and curved surfaces is somewhat difficult due to the fact that the emissivity factors for various surfaces are not the same. This causes a variation in the surface temperatures for a given rate of loss. In order to determine the heat loss through the material it is necessary to know the temperatures at the inner and outer surface and the conductivity of the material at the mean temperature between the two surfaces. Probably the simplest process of calculating the loss through a covering is to make an assumption of the outer-surface temperature and then determine the conductivity of the material at the mean of the surface temperature assumed and the inner-surface temperature.

Loss through the covering should then be calculated for the assumed outer-surface temperature and this loss should be checked against the loss as obtained from the surface-loss equation. If the two losses do not check the assumed outer-surface temperature must be changed according to the indications of the calculation and the process repeated until the two losses check.

In the case of a flat surface the quantity of heat conducted per unit of area and time is given by the equation

$$H = K\ (T_1 - T_3 - T_d) \qquad (1)$$

in which

H = B.t.u. loss per hr. per sq. ft. of surface.
K = thermal conductivity of insulation.
T_1 = temperature of inner surface of insulation.
T_3 = temperature of room.
T_d = temperature difference between outer surface of insulation and room.
X = thickness of insulation.

This equation can be changed to

$$H = \frac{K\ (T_1 - T_2)}{X} \qquad (2)$$

in which T_2 = outer surface temperature, since $T_2 = T_3 + T_d$.

As previously mentioned, the main difficulty in solving this equation is due to the uncertainty of the outer-surface temperature as in most cases the only temperatures known are the steam temperature and the room temperature.

Surface losses from various-diameter canvas-covered pipe insulations are such that the results can be expressed by the equations:

$$T_d = \frac{272.5\ h}{h + \frac{564}{D^{0.19}}} \qquad (3)$$

or

$$h = \frac{564\ T_d}{D^{0.19}\ (272.5 - T_d)} \qquad (4)$$

Loss from a flat surface cannot be expressed from these equations but to enable one to arrive at an approximate flat-surface temperature, it is suggested that the equations be used, assuming D to be a 30-in. pipe, when

$$T_d = \frac{272.5\ h}{h + 295} \qquad (5)$$

or

$$h = \frac{295\ T_d}{272.5 - T_d} \qquad (6)$$

It is understood that this will give only approximate results for flat surfaces and is not based on any flat-surface loss determinations by the author but is only suggested until something more definite is developed.

In the case of a cylindrical surface having a single section of insulation applied, the quantity of heat conducted per unit of area is given by the equation

$$H = \frac{K\ (T_1 - T_2)}{r_1 \log_e \left(\frac{r_2}{r_1}\right)} \qquad (7)$$

It is, however, more convenient to work from the outer surface of the insulation since the loss through the covering must be checked from the loss from the outer surface. In the case of a flat surface, the loss per unit area is the same for the inner and outer surfaces, while the loss per unit area from a cylindrical surface is greater for the inner surface than for the outer surface, or $H = h\ (r_2 \div r_1)$. Therefore

$$h = \frac{K\ (T_1 - T_2)}{r_2 \log_e \left(\frac{r_2}{r_1}\right)} \qquad (8)$$

in which h = B.t.u. loss per hr. per sq. ft. of outer surface.
r_1 = radius to outside of pipe in inches.
r_2 = radius to outside of covering in inches.

Solution of a Problem

The process involved will be illustrated by an example. Determine the heat flow in B.t.u. per hour per square foot of pipe surface through an air-cell covering 1 in. thick on a 4-in. pipe. The temperature of the pipe is 370 deg. F. and the room temperature 70 deg. F.

Assume that the approximate canvas temperature difference at 300 deg. temperature difference pipe to room for a 1-in. thick covering on a 4-in. pipe is 69 deg. The mean temperature of the covering is then equal to (370 + 139) divided by 2 or 254.9 deg. From curve No. 62, the conductivity of air cell at 254.9 deg. is found to be 0.717. The calculated value of $r_2 \log_e (r_2 \div r_1)$ is found to be 1.19 and the temperature difference between the inner and outer surface covering = 370 — 139 = 231 deg., making h from equation (8) equal to $0.717 \times 231 \div 1.19 = 139$ B.t.u. This value is substituted in the surface-loss equation (3) as follows:

$$T_d = \frac{272.5 \times 139}{139 + \frac{564}{7.5^{0.19}}} = 72.3 \text{ deg. F.}$$

It will generally be found that the correct surface temperature will be near the first temperature calculated from the surface-loss equation, as a variation of several degrees in the surface temperature will cause only a slight variation in the conductivity value.

Next, a surface temperature of 72 deg. is assumed. The mean temperature = 256 deg. and the conductivity = 0.72 B.t.u., while the temperature difference between the inner and outer surface = 228 deg. Then,

$$h = \frac{0.72 \times 228}{1.19} = 138 \text{ B.t.u.}$$

Checking again,

$$T_d = \frac{272.5 \times 138}{138 + 385} = 72 \text{ deg. F.}$$

This indicates that 138 B.t.u. is the correct loss per square foot of outer surface. The loss per square foot of pipe surface is then $138 \times 3.25 \div 2.25 = 199$ B.t.u. per hr. per sq. ft.

Problem for Compound Sections

Determination of heat transmission through compound sections is somewhat more difficult than the calculation for single sections, the labor involved in making the calculations increasing as the number of sections is increased.

The equation for compound sections on a flat surface is

$$H = \frac{T_1 - T_2}{\frac{X_1}{K_1} + \frac{X_2}{K_2} + \frac{X_3}{K_3} +} \qquad (9)$$

while the corresponding equation for cylindrical surfaces is

$$H = \frac{T_1 - T_2}{\frac{r_1 \log_e \frac{r_2}{r_1}}{K_1} + \frac{r_1 \log_e \frac{r_3}{r_2}}{K_2} + \frac{r_1 \log_e \frac{r_4}{r_3}}{K_3} +} \qquad (10)$$

or, in terms of the heat loss per sq. ft. of outer surface

$$h = \frac{T_1 - T_2}{\frac{r_3 \log_e \frac{r_2}{r_1}}{K_1} + \frac{r_3 \log_e \frac{r_3}{r_2}}{K_2} + \frac{r_3 \log_e \frac{r_4}{r_3}}{K_3} +} \qquad (11)$$

Practical value of these equations is probably best illustrated by the fact that when insulating high-temperature pipe lines in the past it has been common practice to use a first layer of matted asbestos, held in shape by a silicate-of-soda shell, fiber felted blocks or fire felt, over which better insulators such as multi-ply sponge felt or magnesia are applied. The first layer, composed of a material capable of withstanding high temperatures is supposed to reduce the temperature to which the outer layer is subjected to within its proper working range, but due to the poor insulating value of this class of material many standard specifications, which were arrived at by rule of thumb, do not use a sufficient thickness of high temperature insulation to accomplish this purpose. The following analysis of a section that has been largely used when temperatures of 750 deg. F. prevail will demonstrate the value of computing intermediate temperatures in any section considered, by some such method as that outlined in the following paragraphs:

Conditions: 6-in. pipe at a temperature of 750 deg. F. covered with a 1-in. thick layer of matted asbestos insulation, over which is applied a layer, 2 in. thick, of either asbestos covering or 85 per cent magnesia, the room or air temperature being 70 deg. F.

By computing intermediate temperatures, as outlined below, it is found that when 85 per cent magnesia is used as an outer covering its initial temperature is 606 deg. F. and that when the best asbestos coverings such as multi-ply or sponge felt are used, the initial temperature for these materials goes to 608 deg. F. Some engineers will allow 85 per cent magnesia to be used at this temperature of 606 deg. F., but the damage to asbestos products subjected to such high temperatures as 608 deg. is so serious as to make their use under these conditions anything but advisable.

Various steps involved in the solution of problems of this type will be illustrated by an example. Let it be required to determine the heat flow in B.t.u. per hour per square foot of pipe through a compound insulation on a 6-in. pipe consisting of a first layer of Hi-Temp 1½-in. thick and a second layer of 85 per cent magnesia 2 in. thick. The temperature of the pipe is 750 deg. F. and the room temperature is 70 deg. F.

From conductivity curves Nos. 50 and 57, it is seen that the conductivity of Hi-Temp is slightly higher than that of magnesia, so it may be assumed that a canvas temperature difference slightly higher than for a covering 3 in. thick at 600 deg. temperature difference exists since in this case the covering is 3½ in. thick and the temperature difference is 680 deg. Assume a temperature difference of 46 deg. or a canvas temperature of 116 deg. The total drop in temperature through the two coverings = 750 — 116 = 634 deg. The next step is to assume the temperature drop through each insulation, in order to determine the conductivity value to use. No rule can be given for the first assumption but it will be found that the second one can be calculated very closely. We know from curves Nos. 50 and 57 that the drop through Hi-Temp should be less than the drop through magnesia, so we first assume a drop of 330 deg. F. through magnesia and a drop of 304 deg. through Hi-Temp.

Let T_2 = temperature between the outer surface of Hi-Temp and the inner surface of magnesia, then T_1 = 750, T_0 = 446, and T_2 = 116, and the corresponding mean temperature of Hi-Temp = (750 + 446) ÷ 2 = 598 deg. while the mean temperature of magnesia = (446 + 116) ÷ 2 = 281. From curve No. 57 K, for Hi-Temp = 0.658 and from curve No. 50 K_2 for magnesia = 0.497. Now r_1 = 3.3125, r_2 = 4.8125

$$r_3 \log_e \frac{r_2}{r_1} = 2.55, \text{ and}$$

$$r_3 \log_e \frac{r_3}{r_2} = 2.378.$$

Substituting the values obtained above in equation (11)

$$h = \frac{750 - 116}{\dfrac{6.8125 \log_e \dfrac{4.8125}{3.3125}}{K_1} + \dfrac{6.8125 \log_e \dfrac{6.8125}{4.8125}}{K_2}}$$

= 73.2 B.t.u.

Substituting this value in the surface-loss equation (3)

$$T_d = \frac{272.5 \times 73.2}{73.2 + 343} = 48.1 \text{ deg. F.}$$

This checks fairly closely with 46 deg. first assumed. It is known that, provided the separate temperature drops through each covering were assumed approximately correct, the correct T_d will be near to 48 deg.

Temperature drop through Hi-Temp will be approximately = 3.87 × 73.2 = 283.5 deg. and the drop through magnesia approximately 4.79 × 73.2 = 350.5. Next assume a canvas temperature of 118 deg. with the corresponding total drop through the insulation of 632 deg. F. Since 2 deg. less drop has been assumed through the insulation a corresponding drop of 1 deg. will be assumed through each insulation, or the drop through Hi-Temp = 282.5 deg. and the drop through magnesia = 349.5 deg. The mean temperature of the Hi-Temp then = 608.7 deg. and K_1 = 0.661, the mean temperature of the magnesia = 292.7 deg. and K_2 = 0.501, whence

$$h = \frac{632}{\dfrac{2.55}{0.661} + \dfrac{2.378}{0.501}} = 73.4 \text{ B.t.u.}$$

and

$$T_d = \frac{272.5 \times 73.4}{73.4 + 343} = 48.1 \text{ deg. F.}$$

This value checks with the value of 48 deg. last assumed and the heat loss = 73.4 B.t.u. The total heat loss per square foot of pipe surface per hour is therefore

$$73.4 \times \frac{6.8125}{3.3125} = 150.9 \text{ B.t.u.}$$

and the temperature at the inner surface of the magnesia = 467.5 deg. F.

Compressed Air Piping

COMPRESSOR AIR discharge pipes, states the Compressed Air Society, should be the full size of the discharge opening on the air cylinder. This pipe should drain to the air receiver and have no pockets formed therein. The distance between the compressor and air receiver should be as short as possible, with sharp bends and fittings held to a minimum, thus increasing the efficiency by reducing the friction. A globe or gate valve should never be placed in the discharge line between the compressor and air receiver unless a pop safety valve of sufficient area is installed in the discharge line on the compressor side.

Moisture in air is always a source of trouble where the air is to be used in reciprocating mechanism, for this moisture carried into the machines with the air tends to wash away the lubricant and to increase the wear by leaving bare surfaces in moving contact.

By cooling the air before it passes to the air receiver or pipe line so that the moisture in the air will be condensed and deposited, these troubles are avoided. The air aftercooler has been devised to perform these cooling and drying functions by bringing the hot moist air from the compressor discharge in contact with water-cooled surfaces of such extent and during such a time that the moisture in the air will be condensed and deposited before it can enter the distribution system. Modern air plant installations use an aftercooler and set this between the compressor and air receiver so that any moisture carried with the air after leaving the cooler is collected in the air receiver.

Air receivers are used to equalize the discharge pulsations from the compressor and to deliver a steady flow of air to the service line. They should be of ample capacity and located near the compressor and outside the engine room if possible. The discharge pipe from the compressor should be connected at a point near the top of the receiver and the pipe line to the work should be connected at a lower point. A drain cock should be located at a low point in the receiver for drawing off at regular intervals any accumulated oil, water and impurities.

Pressure gages should be checked with standard gages at regular intervals, making the necessary corrections when a discrepancy is found. The pop safety valve should be of sufficient area to prevent any excessive pressure rise in the receiver in case the unloading apparatus fails to function. In operation, valves should be made to blow at intervals to avoid the danger of sticking. The cubical contents of air receivers, as regularly used, are from 1/6 to 1/10 of the free air capacity per minute of the air compressor used therewith. As large air receivers avoid rapid pressure fluctuations, it is best to be liberal in the size of air receiver used.

Rebuilding an Old Steam Engine Plant

DESCRIPTION OF A PLANT WHICH IS BEING REBUILT. IT FORMERLY BOUGHT STEAM, USED IT AND SOLD IT BACK TO THE ORIGINAL OWNERS

RECENTLY a contract expired in Ludington, Mich., which terminated an agreement under which the Stearns Salt and Lumber Co. had been selling high-pressure steam to the Stearns Light & Power Co. The power company did not own or operate any boilers. The purchased steam was used in various types of noncondensing engines and the exhaust steam was sold to the salt company which then used the low-pressure steam in the process of salt-water evaporation. It was simply a case of a power plant which did not have boilers but bought steam under contract. It used the steam to generate electric power and then sold the steam after it had served its purpose.

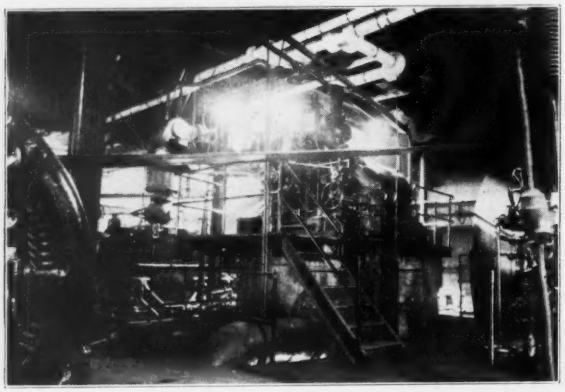


FIG. 1. GENERAL VIEW OF THE MIXED PRESSURE TURBINE

Changed conditions such as the dying out of the lumber business in that section of Michigan, intermittent operation of the salt works and an increasing demand for power brought the Stearns Light & Power Co. up against the fact that it had to have a complete power plant and that a greater degree of economy had to be obtained than was possible from the old noncondensing units. The result is that a boiler plant has been constructed and two modern condensing turbo-generator units have been installed. The old engine units are being either dismantled or held in reserve. In this way economy of operation and continuity of service are being assured.

As originally laid out the engine room covered a floor space 65 ft. by 108 ft. The equipment in this room consisted of the line transformers and the station electrical equipment in addition to a 10-panel Vermont-marble switchboard and the engine units. The first unit installed in the old plant was a 26 by 34-in. noncondensing Montague steam engine which took steam at 90 lb. pressure. Its speed was 90 r.p.m. and it was belt connected to a General Electric alternating current generator rated at 75 amp., 2300 v. and 450 r.p.m. Since steam was furnished from the salt works at 115 lb. pressure it was always necessary to operate this unit at a reduced pressure which was obtained by means of a pressure reducing valve.

This unit, having long ago served its purpose, is being cut to pieces with a blow torch and scrapped. Its appearance at the present time is as shown by Fig. 2. The cylinder has been stripped, the gear and reciprocating parts have been removed and the flywheel rim has been cut away from the spokes. It is but an instance of the passing of another old timer.

Adjacent to and parallel with the old Montague engine is a 21 by 48-in. Allis-Chalmers noncondensing engine which operates at 89 r.p.m. This unit, as did the others, operated against a back pressure of 10 to 15 lb. at which pressure the steam was returned to the salt works. The wheel of this engine was 48 in. by 18 ft. and it was belted to a General Electric alternator which was rated at 2300 v., 75 amp., and 450 r.p.m. This unit will be the second one to be dismantled.

ONE ENGINE TO BE KEPT

Next in order comes the only one of the engine units which will be retained. It is a 30 by 48-in. Murray Corliss operating noncondensing at 90 r.p.m. For the time being this unit will be operated as a spare in case of emergency. It is belted to a General Electric alternator rated at 2300 v., 75 amp. and 450 r.p.m. The fourth engine unit is a 29 by 36 by 46-in. Erie City cross compound. It is direct connected to a 1200-kw. General Electric alternator. The valves of this engine are of cast iron and are not suitable for use with superheated steam. It is also to be dismantled.

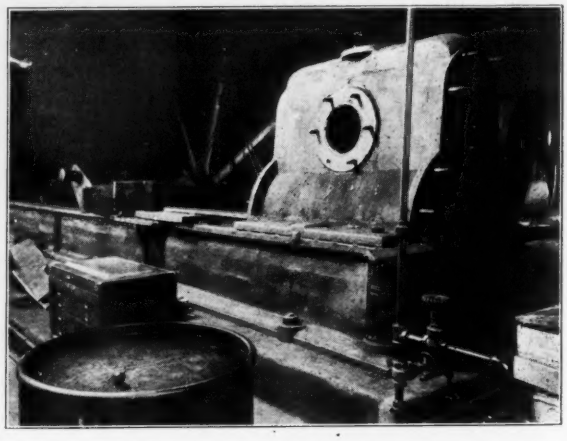


FIG. 2. ALL THAT REMAINS OF THE MONTAGUE ENGINE

Located between the Allis-Chalmers and the Murray engines is a Curtis mixed-flow turbo-generator. The purpose of this unit was to absorb the surplus low-pressure steam discharged by the engine units and not taken by the salt works. It was rated at 157 amp., 2300 v. and 1800 r.p.m. It took steam at 150 and 16 lb. absolute and operated condensing, being served by a C. H. Wheeler Mfg. Co. low-level jet condenser and auxiliaries. Water for the condenser was withdrawn from and returned to Pere Marquette Lake which is connected by an open channel with Lake Michigan.

Up to 1922 the load on this plant consisted of electric service to the town of Ludington and nine adjacent towns. After that this plant was interconnected with two hydraulic developments. The purpose of this tie-in being

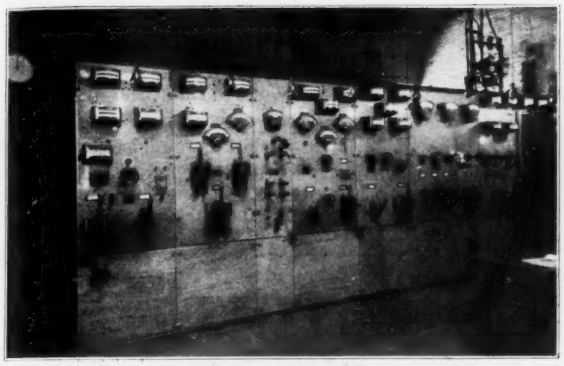


FIG. 3. SWITCHBOARD WHICH WILL BE MOVED TO THE TURBINE ROOM

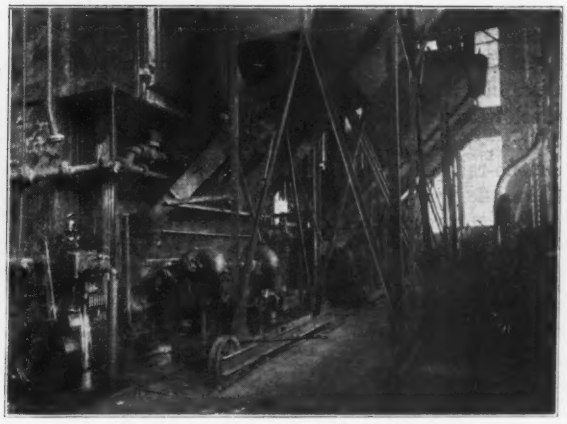


FIG. 4. THESE COAL HOPPERS ARE BEING REMOVED

for the steam plant to help out the hydraulic plants. Voltages sent out from the station are 2300 for Ludington, 6600 on the east line and 13,000 on the south line.

With the expiration of the steam contract, it was at once apparent that a boiler plant had to be constructed. It was, of course, not a good policy to install boilers for the pressure then used in the plant therefore boilers were selected to operate at a pressure of about 230 lb. and a reducing valve was placed between the boilers and the engines so that the pressure in the engine room was about 120 lb.

Boilers Are Rated At 500 Hp.

Three boilers were installed as shown in Fig. 4. These are of the Wickes cross-drum type, each being rated at 503 hp. They are equipped with Westinghouse underfeed stokers, Diamond soot blowers, Stets feed-water regulators and Crane safety valves. The 6-in. non-return valves were made by Lunkenheimer Co., the superheaters were furnished by the Superheater Co. and the piping was furnished by the Pittsburgh Piping and Equipment Co. One radial brick stack, 8 ft. in diameter by 139 ft. high, serves the three boilers.

Other equipment on each boiler consists of a Penberthy injector and Lunkenheimer blowoff valves. The drive shaft for the stokers extends the full length of the boiler room. It is driven at one end by a 4 by 5-in. Sturtevant steam engine and at the other end by an electric motor. The coal is brought in from mines in Kentucky and West Virginia. The present method of coal distribution to the stoker hoppers is as shown in Fig. 4. This is to be changed as will be explained later.

Forced blast is furnished by two Sturtevant turbovane fans, each connected to a Westinghouse turbine. The ducts leading from the fans to the stokers are of sheet metal. A Cochrane lime and soda ash water treating plant of 6000 gal. per hr. capacity takes care of all feed water requirements.

Foxboro boiler instruments have been installed as follows: Each boiler is equipped with an indicating draft meter which shows the ash-pit pressure, draft in the furnace and in the last pass. A flue-gas temperature and a CO_2 recorder is mounted for each boiler. Venturi meters record the steam flow from each boiler and Ruggles-Klingeman regulators control the forced-blast fan and stoker speeds. The dampers are hand operated. At present there are two Cameron feed pumps in operation. They are of the direct-acting type with single cylinder, outside

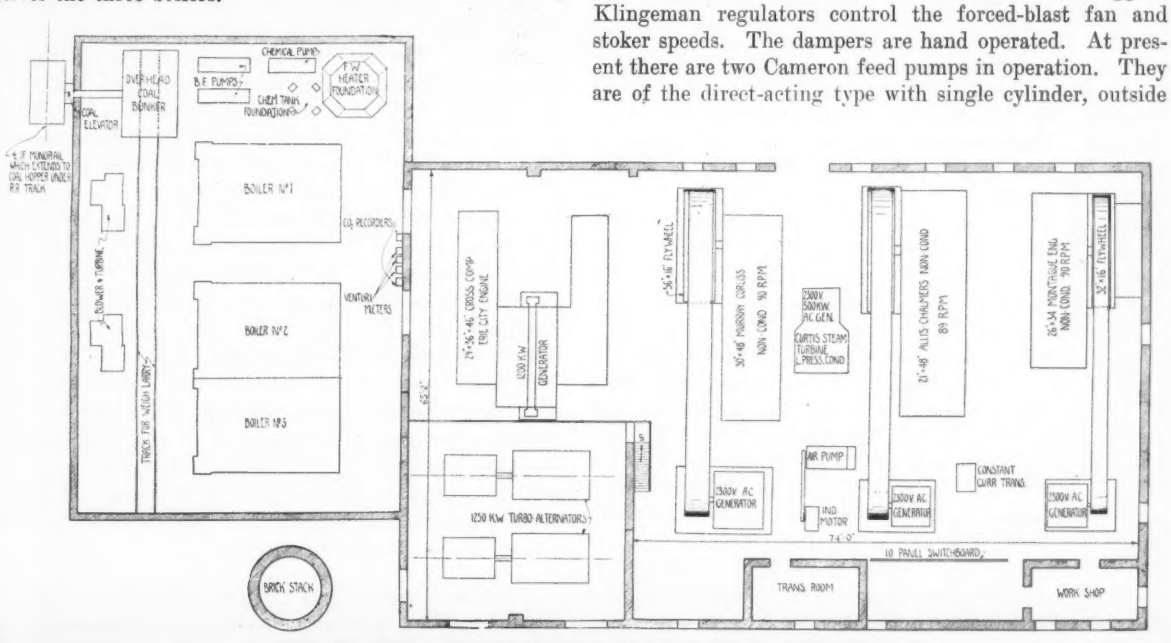


FIG. 5. FLOOR PLAN OF THE PLANT AS IT IS AT PRESENT

packed plunger and are equipped with Hills-McCanna lubricators and Fisher governors.

Ash is dropped from the hand-operated stoker dump-plates into a flat-bottom ash hopper. It is then raked into wheel barrows and taken through a tunnel beneath the boiler operating floor to a point outside the building where a mono-rail hoist picks it up and unloads it on an open dump pile.

Changes which are now under way in the boiler room affect only the coal handling equipment. The movable track hoppers are to be taken out, thus clearing the operating floor. The new coal handling layout will consist of a hopper located beneath an elevated railroad track. A mono-rail hoist will take coal from this hopper and deliver it to a crusher pit located outside of the building. An elevator of 30 T. per hr. capacity, will be built against the building wall to elevate the crushed coal to an overhead bin located in the boiler room near boiler No. 3. A 1000-lb. weigh larry will then distribute the coal from this bin to the stoker hoppers.

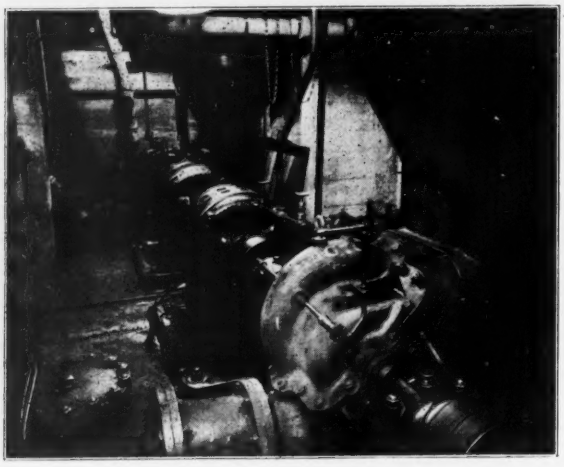


FIG. 6. CONDENSER WATER REMOVAL PUMPS

Economy, consistent with the new development, could not be obtained from the old noncondensing engine units; therefore, two Allis-Chalmers turbo-generators have been installed. These machines are rated at 3600 r.p.m., 3-phase, 60-cycle, 2300 v., 393 amp., 1250 kw. at 80 per cent power factor. Two Allis-Chalmers low level jet condensers serve these turbines. Each water removal pump is rated at 1700 g.p.m., 40 ft. head and 1150 r.p.m. These pumps are arranged with dual drive in the form of a Moore turbine on one end of each pump shaft and a 30-hp. induction motor on the other end. Each turbine is served by an Evactor air pump made by the Croll-Reynolds Co.

Two direct acting Cameron house pumps, each rated at 128 g.p.m., are used to prime the condensers and deliver water to the heater. Condensing water is pumped from the lake into a tank the height of which is about 8 ft. above lake level. The motor driven pumps used for this service are remote controlled from the turbine room. The water flows from this tank by gravity a distance of about 350 ft. to a surge tank located at the plant. The glands of all centrifugal pumps are sealed with treated water for the reason that the foreign matter in the raw water soon clogs up the small pipes leading to the glands.

In this plant firemen are paid a bonus of one cent for each 0.01 lb. of steam evaporated over an actual evaporation of 7 lb. of water per lb. of coal. Thus, if for a given shift a certain fireman showed an actual evaporation of 8.25 lb. of water per pound of coal, his bonus for that shift would be $1.25. This amount would be paid to the fireman and an equal amount to the boiler room foreman.

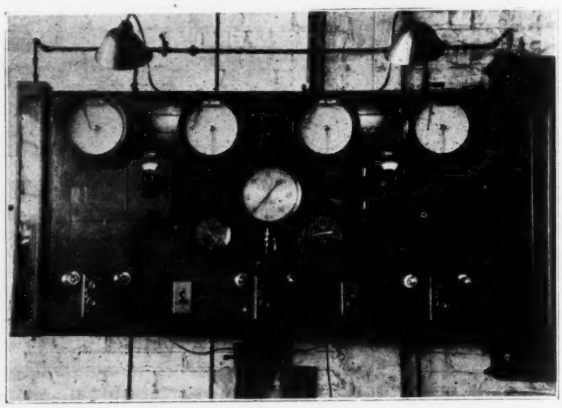


FIG. 7. CONTROL BOARD FOR THE TURBINES AND THE INTAKE PUMPS

The other firemen would not participate in bonus money unless they too exceeded the evaporation of 7 lb. The fireman who shows the highest average actual evaporation for each period of two weeks receives a bonus of $5.00.

With the dismantling of the old engine room it is proposed to move the switchboard to the room which houses the turbine equipment.

DISTRICT and field engineers of the Bureau of Mines, Department of the Interior, who visit coal mines in connection with investigations of explosions, or regarding safety or economic conditions respecting conservation, or in the interest of any Government departments, are instructed to obtain samples of coal for analysis and to procure notes on the various features of the mine and its equipment. The samples taken are forwarded to the Pittsburgh testing station of the Bureau of Mines for analysis and the notes are kept on file at the same station for use in the preparation of material for publication with the coal analyses. A series of technical papers, covering the coal fields of each individual state, is being prepared. These papers include chapters on geology, mining, transportation, use and distribution, etc., together with the chemical analysis of the samples collected. Up to the present time, technical papers containing analyses of Iowa, Kentucky and Ohio coals have been published. Other technical papers containing analyses of Alabama, Virginia, Maryland, West Virginia, Pennsylvania, Tennessee, Utah and Missouri coals will be published within the next few months. Analyses have been made of coal from Kansas, Indiana, North and South Dakota, Texas, Arizona. Colorado, Washington, Idaho, Wyoming, Montana and Illinois samples are being assembled. The entire coal fields of the United States are to be covered.

THE MAN who spends his time and effort in protecting his position from his subordinates is protecting himself against advancement.

Operation of Steam Boiler Plants*

High Boiler Efficiencies and Low Production Costs Are Not Exclusive Products of the Engineering Office. By E. B. Ricketts†

IN THE MODERN POWER station the genius of the designer has provided for us turbine room equipment of such character that, so long as it is maintained in a reasonable state of repair and cleanliness, the efficiency of its operation cannot be materially altered by the operating force. This achievement has been made possible by the fact that in this end of the plant the three fluids—i. e., steam, water and electricity, are substantially constant in quality. Thus, with few, if any, unknown quantities in the problem which confronts the designer, he is able to produce apparatus, the efficiency of operation of which is largely automatic.

Unfortunately, in the boiler room, the materials used are not refined products of known and standard quality but are raw materials which come to us largely as they occur in Nature's storehouse and while much can be accomplished by selecting from the materials available those best suited to our equipment, from present indications the boiler plant which will automatically operate at high efficiency seems still a long ways in the future.

There has seemed to me to be a tendency in recent years on the part of many concerns engaged in steam and power production to overstress the relative importance of design as against operation of boiler plants. In making this statement I do not desire to convey the impression that in designing a boiler plant every effort should not be made to include in our new plants every device which may be reasonably expected to reduce the cost of our product and so to arrange this apparatus as to facilitate the attainment of the desired result; but I do want you to realize that in the last analysis high boiler efficiencies are not made in the drafting room, nor is low production cost exclusively the product of the engineering office. The best designed plants may produce decidedly disappointing results unless consistent, intelligent effort to produce the desired results is constantly put forth by the operators.

It is not my intention in this paper to attempt any comprehensive treatise on boiler plant operation but I will endeavor (through a discussion of some of the more important factors which contribute to efficient boiler operation) to bring to your attention the fact that the basis of good boiler operation is a thorough knowledge on the part of all the men in the plant of the materials and apparatus with which they must deal and the thorough and consistent cooperation of management and men in the common aim of stopping all leaks and keeping them stopped.

Among these factors are: 1. The Human Factor. 2. The Choice of Fuel. 3. Proper Maintenance of Apparatus. 4. Clean Heating Surface.

The Human Factor

Recent years have witnessed numerous improvements in boiler plant equipment tending to decrease manual labor, increase capacity and efficiency and facilitate the control of operations. These improvements have reduced the number of men needed for a given output but the greater complexity of the machinery and the increased value of the output per man have made it even more than ever before vitally important that the men down the line who actually operate the boilers, not only thoroughly understand the machinery and processes over which they exercise control but feel an interest in these processes and in obtaining the best possible results from them.

We cannot afford to pay the price necessary to get firemen who understand the complex theories of thermodynamics. Even if we could get such men at the regular fireman's wage we would probably find them a poor investment because by the time they had learned the practical things which a fireman must know, they would lose interest in their work and a man, no matter how skillful or how learned he may be, is useless on work in which he takes no interest.

As it is, therefore, necessary to recruit our boiler operating force largely among men having limited educational advantages, the question which naturally arises is: "How are we to develop from such material the kind of men required?"

If the primary reason which influences a man in getting a job in a boiler room is because he needs the money and no inducement for interest in the job is offered except a succession of pay days, he will usually learn no more about his work and take no more interest in it than is necessary to continue his connection with the payroll.

Man is so constituted that he must take an interest in something; in other words, he must have a hobby. For some this hobby may be baseball, for others golf, wireless, poker, etc., and once in a while you find a man whose interest is his work. Of the extensive list of hobbies from which a man may choose, there is none more fascinating than operating a boiler and I have often thought that, if we advertised the possibilities of our business with half the skill displayed by Tom Sawyer when he had a job of whitewashing to do, we would have a long waiting list recruited largely from the ranks of the bored and idle rich, ready to pay high for the opportunity of engaging in so attractive a pursuit.

One way to gain a man's interest in obtaining good results is to show him how to get them. If we treat the fireroom force to learned lectures on the thermodynamics of the combustion process, they may come away remembering parrot-like such terms as CO_2 and B.t.u., which information will be about as useful to them as to a parrot, but there are few men who cannot learn by being repeatedly shown. The way to teach a fireman to operate with low excess air is to check his gas analysis and then show him where the excess air is coming from and help him to correct the trouble; by repeated checks of the gas analysis, together with observations of the fire and explanations of the reason for what has been done the fireman will soon get so he can analyze the gas with his eye nearly as well as the chemist can with an orsat. The eye, like any other instrument, however, gets out of calibration unless frequently checked.

In my opinion, about the worst thing which can be done for the efficient operation of a boiler plant is to

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*An address delivered before the National District Heating Association.

†Assistant to chief operating engineer, The New York Edison Co.

clutter up the place with a lot of expensive recording instruments for the exclusive purpose of giving the boss a check on what the men are doing.

I have seen many plants where the management went to the foolish extreme of putting a blind face on the instruments so the operators couldn't see what they were recording. Such a practice is worse than throwing away the instrument because the operator comes to regard the instrument in the same light that he does a spy and instead of trying to get efficiency he will lie awake nights thinking up schemes to beat the gage.

Instruments are a great aid to boiler operation if they are wisely used, but to be useful the accuracy of their calibration must be maintained and the meaning of their indications thoroughly understood by the fireman. If an instrument is not right and cannot be repaired at once, it should be either covered up or taken down and sent to the storeroom, for if an instrument is frequently allowed to run when out of order nobody will pay any attention to it. Where permanent instruments are not available, it is frequently of advantage to give the foreman an orsat apparatus, a flue thermometer and a draft gage and teach him how to use them. Such a practice eliminates the air of mystery which surrounds CO_2. Wherever possible the efficiencies obtained by shifts should be posted in the boiler room; anything which can be done to promote a spirit of rivalry for high efficiency between different shifts or between neighboring plants will bring about team work between management and men, the result of which will add many dollars to the profit side of the ledger.

Choice of Fuel

The cost of fuel often represents 75 per cent or more of the cost of steam production. The choice of fuel may affect the thermal efficiency of the plant 10 per cent or more and the efficieny in dollars in some cases as much as fifty per cent. It is, consequently, of the utmost importance that coal be purchased with a thorough knowledge of the results which it is capable of producing in the plant under consideration. Choosing a coal is much like drilling for oil, a geologist can, from a study of statistics and local conditions, point out a spot where oil is likely to be found but the only way to be certain the oil is there is to drill; so also the chemist can, from a study of the statistics of the coal industry and the local plant conditions, point out certain coals which are likely to give satisfaction in a given plant but the only way to pick a winner is to make careful boiler tests on those coals which the chemist's study indicates to be the most suitable and in the light of the facts thus brought out choose that coal which, while maintaining the desired output, will enable the plant to produce the largest amount of steam for a dollar.

Proper Maintenance of Apparatus

Operators are frequently blamed for poor results when, due to a shortsighted policy on the part of the management, such things as stokers, dampers, baffles, settings, etc., are allowed to get in such a state of disrepair that good results are impossible.

When poor efficiencies are being obtained, all the apparatus should be carefully gone over to see if it is in condition to produce good results and where found defective, should be put in good repair before the fireman is blamed for the results obtained.

Among the items frequently responsible for losses of relatively large magnitude are leaks in baffles, settings and dampers.

Holes in baffles which appear small may cause losses due to excessive flue temperature of as much as 5 or 6 per cent and there are few places in the average boiler plant where such large returns can be obtained from so small an expenditure in money and effort as is possible from keeping the baffles tight. After a tile baffle has gotten in bad shape, it is difficult to make a good job by patching with new tile. The best way which I know of for repairing a leaky baffle is to plaster up the holes with high temperature cement applied by means of a cement gun. Three or four men can repair the baffles on five or six 600-hp. boilers in a day. The cost of this work is nominal compared with the money which it saves.

A low flue temperature does not necessarily mean high efficiency. I have seen many cases where the flue gas temperature was below that of the water in the boiler even when the baffles were in bad shape. This condition was due to bad leaks through the setting. Whether or not the setting leaks can be easily determined by checking the gas analysis in the first pass and flue at the same time; if the flue analysis shows a CO_2 content considerably lower than the first pass, the leaks should be located and repaired. Leaks can be located easily by throwing oily waste on the fire with the damper closed, causing black smoke to come out through all the cracks. The worst leaks are usually due to badly fitting doors and door frames, also at the meeting point of drum and brickwork. These leaks can usually be repaired by pointing up the walls with one of the numerous plastic boiler coating compounds which, due to their property of remaining soft for long periods, are much better than fireclay or cement.

While leaky dampers have little effect on efficiency when the boiler is in operation, they are a serious source of loss when boilers must be banked for long periods. In some tests recently made on banked boilers it was found that with a leaky damper it was difficult to maintain over 3 or 4 per cent CO_2 but when this damper was made tight so that a slight pressure was maintained in the setting, the CO_2 increased to 10 or 12 per cent and the efficiency over a period of 32 hr. with an average output of 10 per cent rating was 68 per cent. The claim has often been made by operators of oil and powdered coal burning plants that their banking costs are much lower than with stokers. In my opinion, this lowered banking cost has been largely due to more attention having been paid to tight dampers.

Clean Heating Surface

Due to the fact that, if the water side of the heating surface is not kept reasonably clean, there will be continuous trouble from loss of tubes, most operators can be relied on to look after the internal cleaning of their boilers but the cleaning of the gas side of the heating surface is frequently only half done. The best method of cleaning the gas side of the heating surface is a matter on which there is a wide divergence of opinion among engineers. It has been my experience that, blowing the tubes with a hand lance while the boiler is in operation (when the boiler is more than 6 ft. wide) is largely a waste of time. There is a wide difference of opinion as to the value of mechanical soot blowers. In some plants they seem to be giving excellent satisfaction and in others just the reverse. Probably this diversity in experience

has been due to some extent at least to the skill with which the installation has been designed and operated. I have seen excellent results obtained by taking the boiler out of service every 10 or 12 days and having it thoroughly blown with a hand air lance, the men working from the inside of the boiler. This system gets the boiler cleaner than I have ever seen a mechanical soot blower do the work but, of course, the interval between cleanings is necessarily much longer than with soot blowers.

There is a hard scale which forms on boiler tubes which cannot be removed by any form of soot blowing. The only way which I have found thoroughly to remove this scale is to wet down the tubes with a hose and while they are wet turn hot feed water into the boiler. This cracks the scale after which it can be usually blown off readily with a hand lance. Several wheelbarrow loads of scale can often be removed in this way after a boiler was apparently clean. Depending on local conditions it may be desirable to wash the tubes at intervals of once a month or once a year.

The part of the tube surface which it is most important to keep clean is the two bottom rows. With some arrangements of setting, soot blowers can be so installed as to keep this surface reasonably clean. Where, on account of the difficulty of protecting the soot blower elements from burning out or because the expense is not warranted, soot blowers are not used, results practically as good can be obtained by banking half the boilers in the plant every night and blowing these tubes with a hand lance through the side door and through doors provided for the purpose in the front wall. Careful tests on the effect of keeping these lower tubes clean indicate that, by following this system, a reduction of 15 to 20 deg. in the flue temperature may be realized.

Some power plant engineers have predicted that the day will soon come when we will operate our boiler plants by turning a crank or pressing a button; and while anything is possible in this day of many marvelous achievements, I feel that the means for accomplishing this result is still some distance in the future. Meanwhile, the efficiency of our boiler plants rests in a large measure with the man behind the shovel and he would be happier working for high efficiency than he is working for six o'clock and pay day.

Features of Airless Injection Oil Engines---I

ADVANTAGES AND DISADVANTAGES OF SOLID INJECTION. TYPES OF SPRAY VALVES USED. VALVES OF DE LA VERGNE ENGINE. BY H. F. BIRNIE AND R. C. BAUMANN

AIRLESS injection oil engines, often referred to as the "direct" or "solid" injection type, differ from the air injection engine in that they do not use highly compressed air to blast the fuel oil into the combustion chamber. Air injection had been perfected long enough to become commercially successful before the same talent, that had developed the air injection, was directed toward accomplishing the same results without the agency of the high pressure air. Of the two systems, therefore, air injection is much more familiar to and more generally understood by the average engineer.

In this discussion the authors are not referring to surface ignition engines but only to those types which depend entirely upon the heat of compression to initiate and insure ignition and not upon uncooled surfaces. Surface ignition engines will be dealt with in subsequent articles.

A comparison of air injection versus airless injection in its present state of commercial development will reveal the following relative merits of the two systems:

ADVANTAGES OF AIRLESS INJECTION

1. A larger percentage of the indicated work of the engine actually developed in the cylinders is realized as useful power at the engine shaft through the elimination of the air compressor which absorbs as much as 7 to 10 per cent of the indicated power of the air injection engine.
2. It becomes possible to use a lower compression ratio since the refrigerative effect of the injection air blast is avoided.
3. Usually cheaper to build.
4. More "fool proof" or safer for inexperienced operatives since all high pressure air piping and storage air reservoirs are avoided.

DISADVANTAGES OF AIRLESS INJECTION

1. Fuel injection valves or spray nozzles and small pump valves on some types are exceedingly sensitive to dirt or solid matter in the fuel oil, hence they require frequent attention and careful handling.
2. For consistently good performance a very effective fuel oil filtering system must be used. This filtering apparatus often assumes quite elaborate proportions.
3. Under average working conditions the combustion is not as good as in the air injection engine.
4. Maximum pressure developed in the cylinder due to combustion is frequently higher than the maximum combustion pressure in the air injection engine in spite of the lower compression pressures used.
5. Pick-up, or speed recovery, with a suddenly applied load is generally not so good.
6. Not as flexible as far as speed changes and load variations are concerned.

Direct injection depends for its success upon the correct correlation of the design of three elements, namely, combustion chamber, fuel injection nozzle (spray valve) characteristic and the fuel injection pump.

One of the first requirements is that the fuel be as finely divided or atomized as possible, before entering the combustion chamber, without curtailing too greatly the penetrating, or driving power, of the spray. Second, the atomized fuel must be sprayed into high temperature air only and no part of the spray must be allowed to impinge upon the wall surfaces of the combustion chamber. Third, if the maximum power is to be realized from a certain cylinder displacement the whole air charge must be grouped in the path of the sprays. Fourth, the mixture ratio of oil to air must be uniform throughout the charge after spraying. In other words, each unit quantity of air should be impregnated with the equal amounts of fuel.

Correct injection pump and nozzle design is the solution of the first requirements while the other requirements are problems of combustion chamber shape and of careful correlation of the spray shape and characteristic to the

combustion chamber shape. In order to gain concrete conceptions concerning the actual parts discussed let us first take up the spray valves.

Two Types of Spray Valves Used

There are two distinct kinds of spray valves used, the automatic and the mechanically opened valve. The mechanical type is necessarily used on all engines operating on the "Vickers" or accumulator system of solid injection. An American example is the Atlas-Imperial.

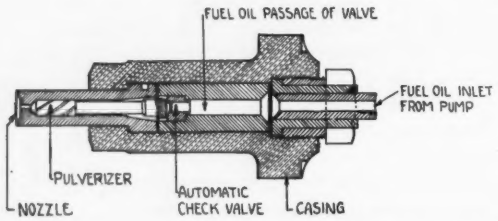


FIG. 1. DE LA VERGNE SPRAY VALVE IS OF THE AUTOMATIC TYPE

Automatic valves are so named because the opening and closing is automatically controlled entirely by the pressure of the fuel oil. This valve is nothing more than a spring loaded check valve and a very fine spray orifice. It is more often used than the mechanically opened valve, not because it produces better results, but because it simplifies construction by eliminating a cam shaft and the various rocker arms and linkage necessary to the mechanical valve. The advantage in simplification is not as great as one might at first think as the construction of the pump becomes more complicated when the automatic valve system is used.

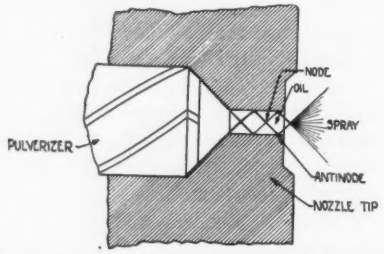


FIG. 2. OIL FLOWS THROUGH A NOZZLE IN WAVES

Producing and forming a fine spray and directing it properly into the combustion space is the one function of the automatic valve. The time of injection is not controlled by the automatic valve since this duty is relegated to the fuel pump which consequently is more complicated than the pump used in connection with a mechanically opened valve. Atomization of the fuel charge is accomplished by forcing the oil through a fine drilling at tremendous velocity.

Figure 1 shows the spray valve used by the De La Vergne Machine Co. of New York, which embodies all the essential and characteristic features of all automatic valves. An outer casing serves to hold in assembly the nozzle tip, pulverizer plug, spring loaded check valve and the pipe connection. The nozzle piece is of steel and drilled hollow to within approximately ⅛ in. of its end. Through the solid end, a fine hole, varying in diameter from 0.028 to 0.034 in. is drilled. A light oil will require the smaller opening, a heavy oil the larger diameter. The 0.028-in. hole is about correct for oils of 28 to 32 Bé. when using two sprays in cylinders of 3000 cu. in. displacement.

It is possible to determine the correct length of drilling only by experiment. The length of the drilling affects the opening or spread of the spray but no definite relation between the two can be established.

Figure 2 is a diagrammatic enlarged sketch showing how the fuel travels through the nozzle. The flow is not rectilinear but rather in waves, reminding one of the travel of sound waves through hollow tubes. That this is actually what happens can be proved by sawing in two longitudinally a nozzle which has seen considerable service. It will be found that, in spite of the nozzle being of steel, annular grooves will be found worn into the circumference of the drilling corresponding to the location of the antinodes of the fuel wave as illustrated in Fig. 2. These worn places are the points where the fuel stream has been deflected back toward the center of the stream.

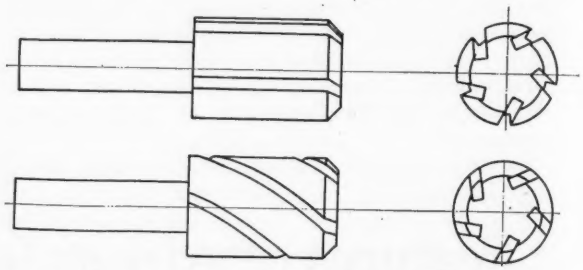


FIG. 3. A STEEL PLUG, WITH EITHER STRAIGHT OR SPIRAL GROOVES, IS PLACED JUST BEFORE THE NOZZLE

It can be readily appreciated that if the end of the nozzle occurs at an antinode the spray will be of a shape different from that which it would possess were the nozzle end to occur at a node or some place between the two. It is probably possible to make the nozzle orifice long enough to dampen out entirely all angular or cross flow and reduce the oil flow to purely straight line translation. Such a nozzle is not used, however, because it adds to the resistance to flow, hence to the pump load, without improving the spray. The nozzle plates are often made of hardened tool steel in order to resist the erosive and cutting action of the fuel stream.

In the majority of engines only one nozzle hole is used per valve. Exceptions are found in the Hesselma engine and some Leissner system engines and the Worthington airless injection engine.

Figure 3 shows a steel plug which is placed immediately before the nozzle drilling when assembled in the valve, and which has spiral grooves cut upon its circumference as a passageway for the oil. Spiral or straight grooves give nearly identical results when used in connection with extremely small nozzle openings such as we are now considering. In some cases the spiral grooves will give a slightly wider spray than the straight channels. If the plug is omitted entirely a much narrower spray will result.

The upper end of the plug serves as a stop to limit the opening of the check valve as it is important that this valve should not leave its seat more than just enough to afford free passageway for the oil, say not more than 1/32

in. The stem of the plug also serves as a guide for the check valve spring. The use of the plug reduces the volume of oil trapped between the check valve after it has closed and the nozzle. The smaller this volume of oil the less will be the objectionable after-dribbling of the oil from the nozzle into the combustion chamber after the pump bypass valve has opened and the spray valve check has closed. In the upper section of the valve body is the check valve, which is usually of tool steel with a hardened valve face. The seat upon which the valve rests is also hardened and narrow, about 1/32 in. wide. The narrow seat helps to keep the valve tight against leaking by increasing the unit pressure between the valve and its seat. This particular valve is comparatively lightly loaded since the spring is of light section. In other types which will be taken up later it will be seen that very powerful springs are used to force the valves to their seats in order to insure a high oil pressure before the valve will open.

Attention should be called to the fact that throughout the valve great care has been taken to avoid pockets or recesses where air might lodge and disrupt the control of the pump over the flow of oil.

Provision is made for a copper gasket in the pipe joint and with a long guide for the pipe which is of very heavy section and able to withstand pressures over 4000 lb. per sq. in. The gaskets must be prevented from spreading out under continued use into the oil channel. On the other hand, if the gasket has too large an internal diameter, it may create an air pocket. The long guide for the pipe connection helps to prevent the pipe from excessive vibration which will eventually cause it to crystallize and break.

Air and Dirt in Oil Cause Trouble

Air bubbles in the fuel lines and dirt in the fuel are the nemesis of the solid injection engine. Air pockets cause coarse spraying during the very first part of the spraying period and also after the pump bypass valve has opened, when all oil movement into the combustion chamber should have stopped. The air causes a gradual building up of pressure on the oil and a slow pressure release instead of abrupt, almost instantaneous changes from no pressure to full spraying pressure and back again to no pressure as desired.

Solid particles in the oil lodge under the seats of the small valves both in the pump and in the spray nozzles and prevents them from seating. If the check in the nozzle does not hold tight, gases from the cylinder will blow back through the spray orifice after the fuel pump bypass valve has opened. This leads to an accentuated case of air binding and causes erratic firing and poor spraying.

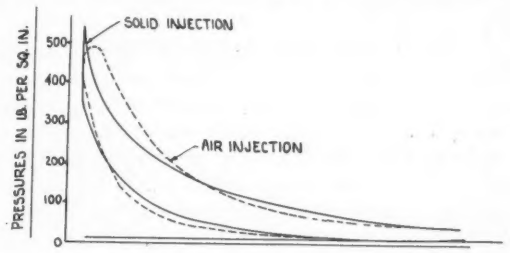


FIG. 5. COMPARATIVE CARDS FOR AIR AND AIRLESS INJECTION ENGINES AT FULL LOAD

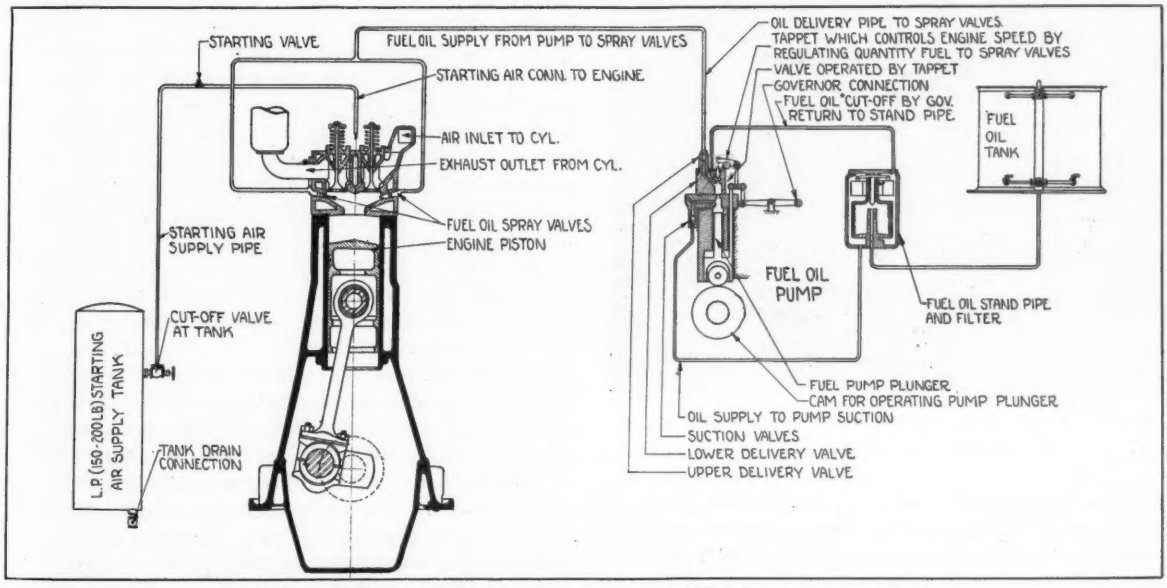

STARTING VALVE
FUEL OIL SUPPLY FROM PUMP TO SPRAY VALVES
STARTING AIR CONN. TO ENGINE
AIR INLET TO CYL.
EXHAUST OUTLET FROM CYL.
FUEL OIL SPRAY VALVES
ENGINE PISTON
STARTING AIR SUPPLY PIPE
CUT-OFF VALVE AT TANK
L.P. (150-200 LB.) STARTING AIR SUPPLY TANK
TANK DRAIN CONNECTION
OIL DELIVERY PIPE TO SPRAY VALVES
TAPPET WHICH CONTROLS ENGINE SPEED BY REGULATING QUANTITY FUEL TO SPRAY VALVES
VALVE OPERATED BY TAPPET
GOVERNOR CONNECTION
FUEL OIL CUT-OFF BY GOV.
RETURN TO STAND PIPE.
FUEL OIL TANK
FUEL OIL PUMP
FUEL OIL STAND PIPE AND FILTER
FUEL PUMP PLUNGER
CAM FOR OPERATING PUMP PLUNGER
OIL SUPPLY TO PUMP SUCTION
SUCTION VALVES
LOWER DELIVERY VALVE
UPPER DELIVERY VALVE

FIG. 4. WORKING DIAGRAM OF DE LA VERGNE SOLID INJECTION ENGINE

The oil in the pipe lines is sometimes driven so far back from the nozzles that one or more complete pump stroke is required again to get the oil to the nozzles.

When the spray from a valve of this type is viewed in the air it will show a perfect cone shape having an included angle of about 20 deg. It will penetrate air at atmospheric pressure several feet. Unfortunately little experimental work has been carried out to ascertain definitely just what form a spray will assume when directed into air of greater density such as in the combustion chamber of the engine where the pressure is usually about 350 lb. per sq. in. gage at the end of compression, representing a ratio of about 10.5 to 1.

Certain authors on the subject have stated that according to their calculations a spray could not penetrate air

of this density more than ⅝ in. irrespective of the pressure of the oil behind the nozzle. Others have stated that they could not get a penetration of more than 2 in. in a combustion chamber. These statements are erroneous, as the authors have personal knowledge of much greater penetration with very similar nozzles to those just described when spraying against compression pressures of 340 lb.

Penetration of Spray Is Important

Atomization and penetrating power are both essential requirements of a good spray. Unfortunately, however, the two qualities are incompatible since atomization can only be improved at the expense of penetrating ability. Of the two, it is more important first to obtain the necessary penetrating power to throw the oil into all the recesses of the combustion chamber and then accept whatever degree of atomization will accompany this penetration. A spray which, when viewed in the air, is wide and finely divided will give poorer results when used in an engine than one which has greater driving power and less atomization.

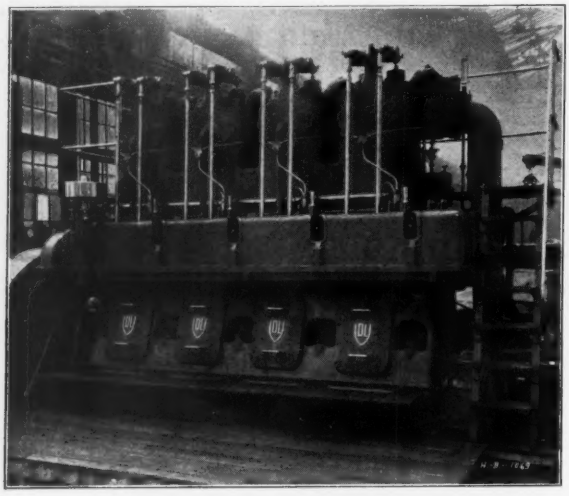


FIG. 6. INDIVIDUAL FUEL PUMPS ARE USED FOR EACH CYLINDER OF DE LA VERGNE ENGINE

Before proceeding to the description of other valves, the general design of the De La Vergne system should be followed up in order to become acquainted with the functioning of the valve in relation to the other components of the engine fuel system. Figure 4 is a diagrammatic layout of the complete system.

Essentially the combustion chamber is the shape of two cones intersecting at their bases and with one spray nozzle at the apex of each. The combustion chamber proper is separated from the cylinder by water cooled partition walls having a restricted opening connecting the combustion chamber with the cylinder, the object of which is to produce a turbulence of the air charge during the injection period. The chamber is shown in Fig. 4.

By this design all the air charge is grouped directly in the path of the two oil sprays so that all the air available is in a postion to assist combustion. The violent turbulence brought about by the restricted communication between the cylinder and combustion chamber fosters a very rapid combustion, so rapid in fact that the larger percentage of the burning takes place at constant volumes giving in part at least an Otto cycle card.

Figure 5 shows a typical card superimposed upon a typical air injection Diesel card. The rush of air up into the combustion chamber also serves to deflect the oil sprays from impinging upon the cold walls should the penetration of the sprays be sufficient to project the oil past the center of the cylinder.

Since both exhaust and intake valves open directly into the combustion chamber the scavenging is very complete. The compression pressure is about 330 lb. gage and the maximum pressure as the result of combustion about 550 lb. The engines are rated upon a B.M.E.P. basis of 64 lb. and will develop with satisfactory combustion a B.M.E.P. of approximately 72 lb.

Figure 6 gives a general idea of the engine and shows plainly the position of the individual fuel pumps, one for each cylinder. The pumps are cam operated from the half speed lay shaft. The levers seen at each pump lift the plunger when it is desired to prime the pump and fuel lines before starting.

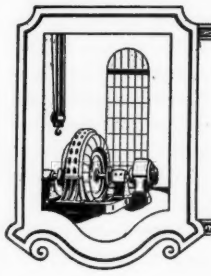
From each fuel pump a line goes to a tee and branches off to the two spray valves of each cylinder. The pump plunger is of hardened steel, ground and lapped to its cylinder so that no packing is required. A stationary copper obturator ring is used at the upper end of the cylinder to help prevent leakage. The crosshead which acts upon the plunger carries a roller which rides on a quick rising cam. The plunger crosshead also lifts a small lever which actuates the bypass valve. The exact time of opening of the bypass valve is under the control of the governor, at light loads the valve opens early during the upward delivery stroke of the plunger, at full load the valve opens near the end of the stroke.

In order to increase the abruptness of fuel delivery, about 0.01 in. clearance is allowed between the plunger roller and the cam which strikes it. One of the early difficulties encountered in the use of a cam and roller driven fuel pump was the sticking of the roller on its pin. This difficulty was overcome by making the roller diameter great in comparison to the diameter of the pin and by more effectively lubricating this bearing by pressure oiling.

Two suction valves in series are used to diminish pump slippage losses. The single discharge valve might be dispensed with if the check valve at the spray nozzle would remain tight, but when this valve fails to hold the discharge valve at the pump prevents complete air binding of the pipe lines by gases blowing back from the combustion chamber. The discharge valve also facilitates priming by preventing the oil in the lines from flowing back through the bypass valve when barring over the engine.

In a subsequent issue the study of airless injection oil engines will be continued.

The National Safety Council, in a recent publication, sets forth nine beneficial effects of proper painting as an aid to interior illumination. These are: 1. Reduction of accidents; 2. Greater accuracy in workmanship; 3. Decreased spoilage of product; 4. Increased production for the same labor cost; 5. Less eye strain; 6. Better working conditions; 7. Less labor turnover; 8. Better order, cleanliness and neatness in the plant; and, 9. Easier supervision of the men.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Fundamentals of Electrostatic Precipitation

THE RECENT APPLICATION OF ELECTRICAL PRECIPITATORS AT THE TRENTON CHANNEL STATION MAKES THE SUBJECT ONE OF INTEREST TO THE POWER PLANT ENGINEER

IN 1908 DR. F. G. COTTRELL brought to light a new process for the precipitation of dust particles from gases by means of an electrostatic field. From the beginning, this process gave promise of considerable success and has been used extensively in the smelter and refining industries. Just recently, however, an application of this process has been made in the power plant field for the precipitation of flue dust from the gases of combustion of pulverized fuel furnaces. From this point of view, a description of the process should be of interest to the power plant engineer.

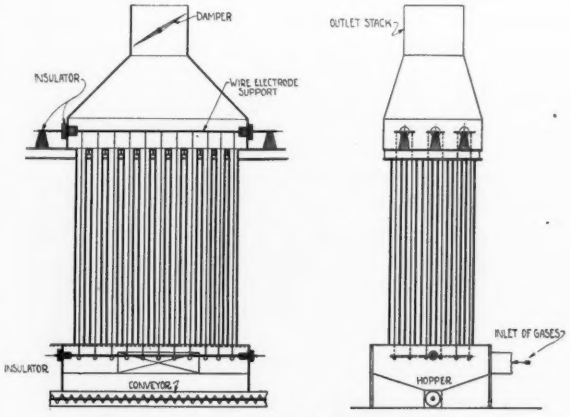


FIG. 1. DIAGRAM OF A PIPE TREATER

The process, developed out of what had been previously considered merely an interesting phenomenon, is essentially as follows:

A gas, or air stream, carrying solids or liquids in suspension, is subjected to the influence of a strong electrostatic field produced by a high unidirectional potential for the purpose of charging the dust particles and throwing them out of the gas stream. The gas is passed through the space between suitable electrodes and this space is made part of a high potential circuit by placing it in series with the high potential winding of a transformer. Some means must, of course, be employed to rectify the high potential alternating current delivered by the transformer. This may be accomplished by a revolving switch, Kenotron rectifiers, or, the direct current may be supplied directly by generators or batteries.

In practice, the precipitator consists of a large number of oppositely charged electrodes, the cathods being made of relatively small surface as compared with that of the anodes. The cathod usually referred to as the "discharge" electrode is made small so as to produce a high potential gradient near its surface. This electrode serves only as a charging electrode. The "collecting," or positively

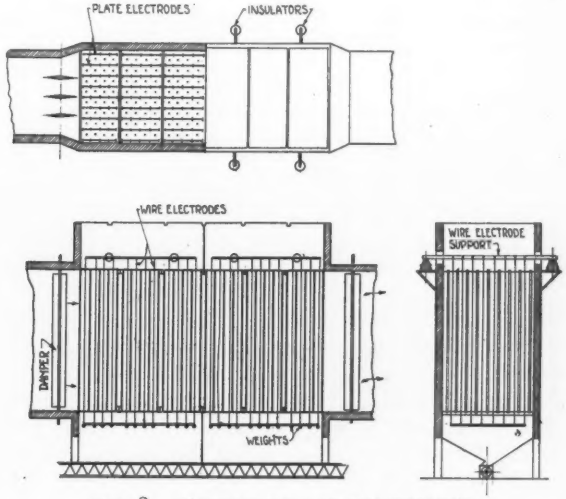


FIG. 2. DIAGRAM OF A PLATE TREATER

charged electrode, is made with a relatively large surface and serves as the principal collecting electrode because most of the dust is driven to it. For purposes of safety, this electrode is made the grounded side of the system .

PRACTICAL CONSTRUCTION OF PRECIPITATORS

In actual construction, the form of the electrodes varies considerably. The discharge electrode may consist of wires, chains, edged strips or serrated edges. Collecting electrodes may consist of plates, pipes, screens, or any other form or arrangement of conductors that will establish low field concentration and thus minimize or prevent corona discharge therefrom.

Precipitators may be classified roughly as being of the pipe type or plate type. In the pipe type precipitator, the collecting electrodes consist of a bank of vertical pipes through the center of which is hung a wire or chain which serves as the discharge electrode. The dust laden gas enters at the bottom and passes upward through the pipes. Most of the dust is precipitated on the inner surface of the pipes.

Somewhat similar to this in principle is the plate type of treater, in which the pipes are replaced by vertical, plain

or corrugated iron plates. Vertical chains or wires are suspended between these plates in the same manner as in the pipe treater to serve as discharge electrodes. Figure 1 is a schematic drawing of a pipe treater and in Fig. 2 is shown a plate treater. The potential between the electrodes in different installations ranges from 20,000 to 100,000 v.

It may be well here to discuss briefly the commonly accepted theoretical explanation of the manner in which the dust particle is charged and precipitated. This is accomplished through the ionization of the gas which carries the particles.

Theory of Action

When the potential of the discharge is raised above a certain critical value, a corona discharge is established and

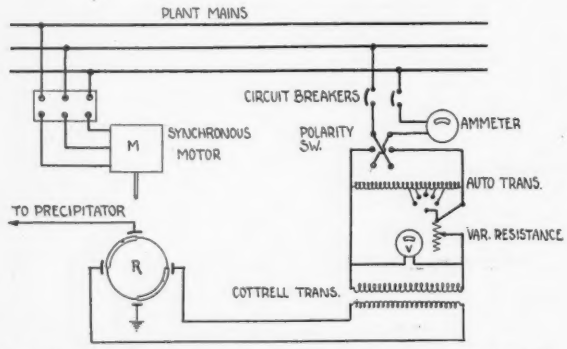


FIG. 3. WIRING DIAGRAM OF THE SYNCHRONOUS MOTOR SYSTEM

the gas immediately around the wire becomes ionized. Electrons liberated in the immediate vicinity of the discharge electrode are acted upon by the high potential electrostatic field existing between electrodes and are drawn to the positive or collecting electrode. So far, it must be remembered we are only considering the electron, not the dust particle which we are trying to precipitate. The electrons, however, in passing to the collecting electrode collide with the dust particles in their path, thus charging them negatively. Having acquired a negative charge in this manner and being in a high potential electrostatic field, the dust particles are drawn to the collecting electrode and hurled against it with considerable force where they give up their negative charge and cling to it by adhesion. There are many interesting speculations, such as the possibility of some of the particles being charged by electrostatic induction; the effect of the electric wind caused by the electron stream in aiding precipitation and the indication that some of the particles must be charged positively on account of the deposit which is always found on the discharge electrode but these are beyond the scope of this article.

In the design of a precipitator it is of less importance to know just how the particle is charged than it is to know in just what manner it may be enabled to give up its charge to the electrodes. It has been found in practice that a short time after the precipitator is put in action, the precipitated material collects on the electrodes, producing an insulation coat which the electric charges cannot penetrate. The degree to which this action takes place depends to a large extent upon the material being precipitated.

The main problem in the design and operation of electrostatic precipitators is the production of a suitable high tension direct current. Direct current generators could be used, of course but their expense makes their use prohibitive for the ordinary commercial type of apparatus. Some sort of rectifying devices are, therefore, usually provided, which will convert alternating current at from 25,000 to 40,000 v. into direct current.

Two systems are in common use. In one, low tension alternating current is fed to transformers direct from the regular three phase system and after being stepped up to a high voltage is rectified by means of a mechanical rectifier driven by a synchronous motor.

In the other system, a motor is used to drive a single phase, four-pole generator which supplies power to the low tension windings of a step up transformer, the high tension output of which is rectified by a rectifier mounted on the motor generator shaft.

Of the two systems the former is the cheapest to install but has the disadvantage that it needs careful attention. The synchronous motor system must be watched carefully when starting up, first to secure proper polarity and then to observe that a slip does not take place after starting, due to the momentary low voltage when the polarity could be reversed by the motor slipping one pole. Another disadvantage of this system is that the precipitator circuit is connected directly to the mains serving other departments of the plant or factory and any disturbance may be reflected back on these mains.

The motor generator system is more expensive to install but possesses the advantage of easy voltage regulation, and since the generator and rectifier are mechanically connected, the rectifier is always in synchronism with the

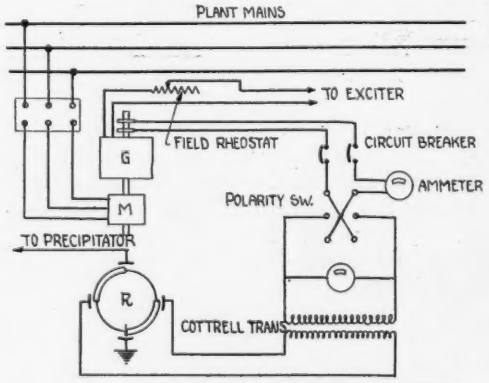


FIG. 4. THE MOTOR GENERATOR SYSTEM

current it is rectifying. Furthermore, there is no electrical connection between the precipitator circuit and the power mains and this eliminates all possibility of disturbances from this circuit being reflected back on the factory mains. As stated above, however, the disadvantage of the motor generator system lies in its first cost and in the fact that a direct current supply is needed for generator field excitation. This usually calls for a small motor driven exciter.

These are the two systems for the production of high voltage direct current in commercial use. Diagram of the wiring connections for each of the systems are shown in Figs. 3 and 4.

In Fig. 5 is shown a photograph of a typical mechanical rectifier used with electrostatic precipitation apparatus.

It consists of a Bakelite disk to the periphery of which are attached two quadrant metal strips opposite each other constituting moving conductors. The four stationary shoes are so mounted that they may be rotated about the disk through 90 deg. by means of a hand wheel, pinion and gear segment. The length of the stationary shoes and the length of the moving conductors determine the length of contact on the wave and the position of the shoes about the disk, as adjusted by the hand wheel, determines the position of the wave rectified. On the rectifier illustrated the shoes cover approximately 25 per cent of the wave.

While these mechanical rectifiers are not entirely satisfactory, they are simple and substantial in construction and embody features of reliability not yet attained in other types of mechanical rectifiers. The greatest objection to their use is the fact that the high tension current is made and broken in air, thus producing high frequency oscillations in the circuit.

A type of rectifying equipment, although not used at the present time in precipitation work but which gives great promise of success is the Kenotron or vacuum tube

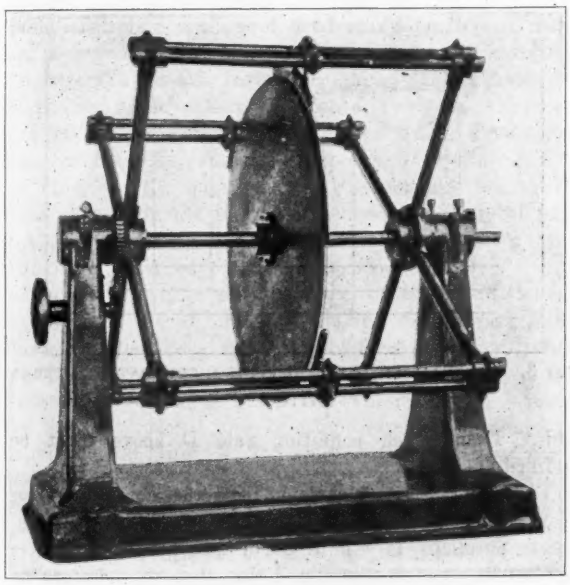


FIG. 5. TYPICAL MECHANICAL RECTIFIER

rectifier. The Kenotron provides a simple means of converting alternating current of any voltage into direct current and has no moving parts. It is compact, simple to operate and when properly designed delivers a direct current that is remarkably free from ripples. These rectifiers are rapidly being developed paticularly in connection with radio transmitting apparatus and there is absolutely no reason why they cannot be developed to take care of electrostatic precipitating apparatus. In Fig. 6 is shown a diagram of a Kenotron rectifier, delivering power at 12,000 v. direct current, from 3 phase, 220 v. alternating current. The direct current voltage variation of this rectifier is less than one-tenth of one per cent.

Applications of Electrostatic Precipitation

As stated in the beginning of this article, electrostatic precipitation has been used extensively in the smelter industry for removing solid material from smelter gases. It has also been used successfully in cement mills. Within the past year, however, an application of the system has been made in the power plant field. This is the installation at the Trenton Channel Station of the Detroit Edison

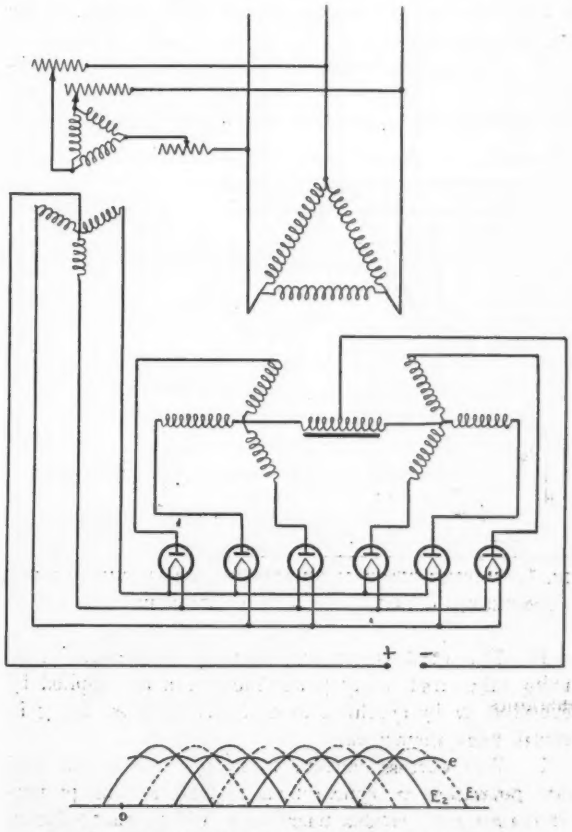


FIG. 6. DIAGRAMMATIC CONNECTIONS OF A 6-TUBE KENOTRON RECTIFIER

Co. It is well known that with pulverized coal furnaces, a considerable quantity of fine cinders flue dust passes up the stack, and in some communities causes annoyance. By the installation of a Cottrell precipitator in the breeching leading to the stack, it is believed that trouble due to the ejection of cinders from the stack will be practically eliminated.

Fibre, tile and stone ducts are the kinds most generally used in underground cable work, although several other kinds are used locally and may be satisfactory under special conditions.

Fibre duct is fast becoming standard, although some of the large companies use clay and stone duct. Fibre duct has the advantage of light weight, thus reducing the freight and teaming charges, of being smooth inside and furnishing a comparatively soft surface over which to draw cables, thus insuring that they will not be scratched or damaged during installation. Also, the breakage of fibre duct is very small and, owing to the self-aligning type of joint used, they need not be laid by skilled labor, thus reducing the cost of laying, while, owing to the larger lengths of the individual piece, there are less joints to leak.

Operation of A. C. Generating Apparatus---VI

CONCULSION. SUMMARY OF PRINCIPLES AS APPLIED TO GENERATORS. HINTS REGARDING CARE OF MACHINES. BY V. E. JOHNSON

IN REVIEWING this series of articles we find that the application of alternating current theory brings out the following points:

A. That power factor of the connected load is determined by the nature of the component parts and can not be changed except by changing the nature of the load itself.

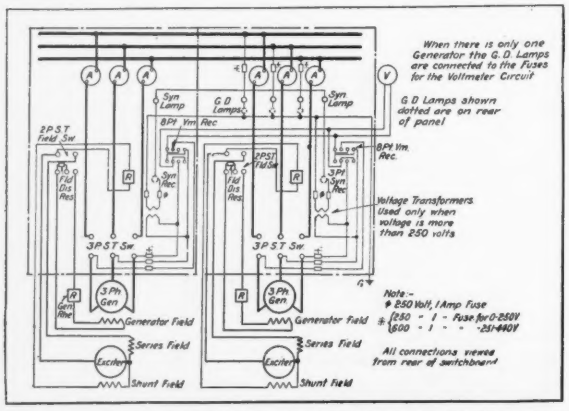

When there is only one Generator the G.D. Lamps are connected to the Fuses for the Voltmeter Circuit
G.D Lamps shown dotted are on rear of panel
Voltage Transformers Used only when voltage is more than 250 volts
All connections viewed from rear of switchboard
Generator Field
Series Field
Shunt Field
Exciter

FIG. 1. WIRING DIAGRAM OF ALTERNATORS HAVING DIRECT CONNECTED EXCITERS WITH NO COMMON EXCITER BUS

B. The wattless current taken by a connected load having other than unity power factor can be supplied by generators or by synchronous motors, the latter being in general more economical.

C. The wattless current taken by a connected load from generators or synchronous motors, can be proportioned among the various machines at will by manipulation

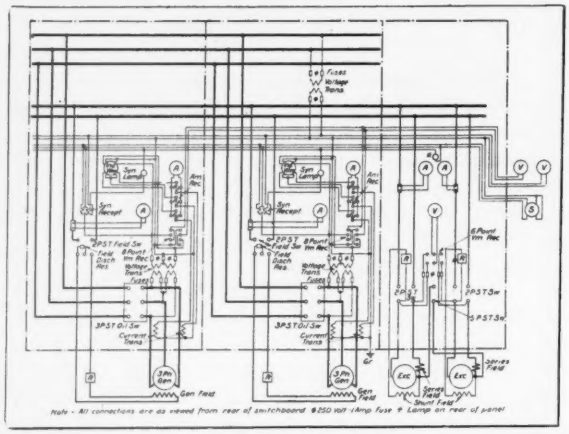


FIG. 2. DIAGRAM OF A BOARD CONTROLLING TWO GENERATORS HAVING A COMMON EXCITER BUS AND SEPARATELY DRIVEN EXCITERS

of the field excitation—always, however, within the limits of the machine capacities.

D. Field adjustment can be used to transfer wattless current from one machine to another but it has no effect on the power current. Load division in kilowatts can not be obtained by field adjustment but is dependent on the amount of energy supplied by the prime mover. This is controlled by the governor or by hand.

E. A generator supplying lagging currents to a connected load has its fields demagnetized by the stator current, so that a greater excitation is required than for the same machine under unity power factor or loading current conditions.

F. A generator supplying loading currents to a connected load has its field strengthened by the stator currents, and so requires less excitation than the same machine under unity power factor or lagging current conditions.

G. Generators must be in exact synchronism and phase when paralleled. Once connected they tend to remain in step up to the capacity of the machines.

H. Generators can not be paralleled at all unless they have the same frequency, the same number of phases, and the same voltage.

I. The relations between generators become complicated in systems which have long lines and distributed

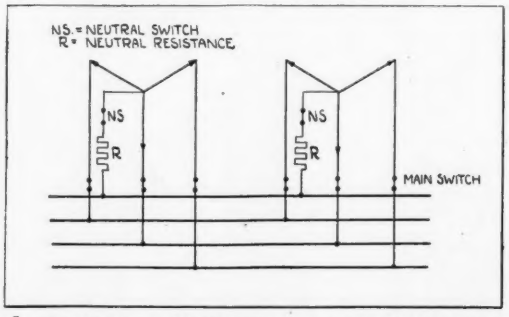


FIG. 3. DIAGRAM SHOWING USE OF A SEPARATE NEUTRAL SWITCH

loads. Under such condition rule D above must be modified.

In Fig. 1 is a sketch showing the actual connections for a low voltage switchboard controlling two 3-phase generators in parallel. It will be noted that here each exciter supplies its own generator, and that there is therefore no need of an exciter bus.

In Fig. 2 is a diagram of a board for controlling two high voltage generators. In this sketch the exciters are connected to a bus. This is desirable in stations where excitation is supplied from large steam or motor driven sets. The former scheme, however, is simpler, and for many installations preferable. With one exciter per generator it is often possible to eliminate the generator rheostat entirely, and so save space and reduce first cost.

We have stated that sometimes the neutral on Y-connected generators is brought out. It should be noted that when this is done, only one generator at a time should be connected to the neutral or ground unless a preventive switch is usually used. See Fig. 3. A neutral switch is usually used. Without going into details it may be stated that if two machines have their neutrals connected without resistances a heavy, and often destructive, current will flow.

The mechanical care of alternators is considerably

simpler than that of direct current machines in that there are no commutators and brushes to care for. If an alternator is kept clean and free from dust, is given ventilation sufficient to keep the surrounding air down to the specified temperatures, and is not overloaded, it will run practically forever—as it has nothing to wear out, except bearings and collector rings.

A good coat of insulating paint now and then will prevent loosening of the insulation around the coil ends. Care should be taken to see that this paint is dry before the machine is used, as wet paint is a partial conductor. This is particularly important in high voltage machines.

If an alternator becomes wet from a broken water pipe, flood or other cause—it may be dried out by runing it under short circuit—reducing the excitation so as to circulate only a safe current. At intervals the insulation resistance should be taken.

The exciter should be cared for in the same manner as any other d. c. machine, it being borne in mind that it is a very important part of the system.

There are various types of generators in general use. Their care and maintenance differs according to their design, but the general principles brought out by these articles apply to them all. Specific instructions for the care of any particular unit may be obtained from the manufacturer.

Many Developments in Hydroelectric Field

REPORT OF HYDRAULIC POWER COMMITTEE OF N. E. L. A. OUTLINES FEATURES OF NEW PROJECTS AND PROBLEMS OF OPERATION

THIS year's report of the Hydraulic Power Committee of the National Electric Light Association covers a variety of subjects, in considerable detail, which are of interest to both designers and operators in the hydroelectric field. Control and outlet works for diversion dams and storage reservoir takes up a good share of the report. Pitting of hydraulic turbine runners, present status of draft tube developments, lubrication methods, inspection and maintenance methods and water wheel testing are some of the other subjects covered.

This year, the manufacturers' statements of interesting developments in the hydraulic field for 1923 are of particular interest because of the number of unusual projects which are under way or have been completed.

In addition to pointing out the importance of the installation of the 70,000-hp. units for the Niagara Falls Power Co., the Wm. Cramp & Sons Ship & Engine Building Co. also call attention to the Holtwood plant of the Pennsylvania Water & Power Co. The units at this plant are the conventional type of runner and are designed to deliver 20,000 hp. under the head of 62 ft. Each of these 20,000-hp. single runner units is installed in the space originally intended for a double runner 13,500-hp. unit.

SPIRAL DRAFT TUBE A NEW DEVELOPMENT

Another feature of the installation is the use of a Moody spreading draft tube of a type such that the discharge portion of the water passage is of spiral formation. The draft tube is designed for minimum space requirements and Taylor stay vanes are used at the lower end of the barrel. This is believed to be the first applicaton of the spiral draft tube in any large installation.

Another installation of particular interest is that comprising two 12,000-hp. I. P. Morris turbines for the Hollinger Consolidated Gold Mines, Ltd., being built by Dominion Engineering Works, Ltd. These turbines will be equipped with Moody ejector draft tubes for the purpose of increasing the power output by the use of surplus flow during times of high tailwater and, consequently, impaired head. This is the first large installation of turbines equipped with self-contained ejectors. Inherent characteristics of the ejector turbine are its economical operation during the period of normal head and limited supply of water and its ability to maintain the normal output during times of excess flow in the river and impaired head. The turbines are of the conventional type and when operating under normal head the ejector gate is closed and the contour of the draft tube, which is of the spreading type, is unbroken. When the tailwater rises and the head is decreased, the ejector gate is opened allowing an auxiliary flow of water to be bypassed, from the casing directly into the draft tube immediately below the runner, without going through the runner. The injection of the auxiliary flow creates an additional draft head which offsets the effect of the rise in tailwater.

FIG. 1. HUGE RUNNER FOR 70,000 HP. TURBINE FOR THE NIAGARA FALLS POWER CO.

Progress in the application of the Moody diagnoal propeller runner which is a development of the Cramp organization, has been towards its use in the field of higher heads. This extension of the application of the propeller type turbine has been made despite many predictions, particularly from abroad, that this type of machine was not suitable for heads greater than 30 ft.

Two propeller type turbines of 28,000 hp. each have actually been in continuous operation for over a year, under heads varying from 18 ft. to 50 ft. and their opera-

tion is said to be entirely successful throughout this range of heads. There has been no serious pitting or corrosion, nor lack of steadiness of operation. The specific speeds actually developed have ranged from 173 under 47.5-ft. head to 230 at 23-ft. head, measurements of power output having been secured at both of these values of head. Moreover, the power output under all conditions observed is in entire agreement with the results stepped up from model tests in the I. P. Morris laboratory on a 16-in. turbine

FIG. 2. PROPELLER TYPE RUNNER FOR 28,000-HP. UNIT FOR MANITOBA POWER CO.

and from Holyoke tests on a 35-in. turbine of homologous form, with a slight increase in the power delivered, attributable to the large dimensions of the full sized turbines. When operating under a head approaching 50 ft. the runners of these turbines are located with the discharge edges of the blades about 3 ft. above the tailwater level.

30,000-HP. PROPELLER TYPE UNITS

In this report, the Cramp Co. also calls attention to the design of four units of still larger capacity for the St. Maurice Power Co.'s La Gabelle development. These turbines are remarkable as being the highest powered propeller type units yet undertaken and they are to operate under a higher head than ever before utilized with this type of turbine. The turbines will be of 30,000 hp. capacity and are designed to operate under a head of 60 ft. at a speed of 120 r.p.m. The runners are of the Moody diagonal propeller type and measure 16 ft. in diameter over the blade tips. They will operate at a specific speed of 125. These units are equipped with Moody spreading draft tubes with complete central core extending the full length of the tube and made continuous with the inner wall of the runner passage. This same construction of core was adopted in the Manitoba installation. As in the previous installation, separate stay vane castings set in the concrete are used, both in the casing and at the lower end of the draft tube.

The St. Maurice units will differ from those at Manitoba in the form of discharge passage between the end of the spreading portion of the draft tube and the point of final discharge. In La Gabelle plant spiral discharge passages will be used.

In addition to the above installations, diagonal propeller type turbines have been used in the following plants, designed by the I. P. Morris Department, which are now in commercial operation: Spruce Falls Co., Ltd., one unit, 2500 hp., 30 ft. head, built by Dominion Engineering Works, Ltd.; Dryden Paper Co., one unit, 1400 hp., 29 ft. head, built by Dominion Engineering Works, Ltd.; Anson Plant of the Great Northern Paper Co., Madison, Me., four units, 1500 hp. each, 20 ft. head, built by The Wm. Cramp & Sons Ship & Engine Building Co.

According to the Allis-Chalmers Mfg. Co., the year 1923 seems to have broken all previous records as to the horsepower of hydraulic turbines contracted for as the total is over 500,000 hp. made up of 60 units. A large amount

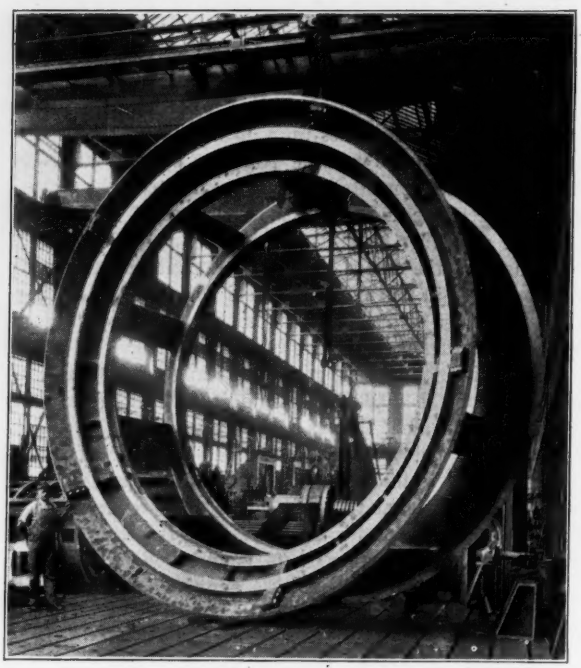


FIG. 3. CAST STEEL SPEED RING FOR 40,000-HP. UNIT FOR THE QUEBEC DEVELOPMENT CO. WEIGHS 48 T.

of this horsepower was taken in one contract, undoubtedly the largest contract for hydraulic machinery that has ever been let, both from the standpoint of actual money values and horsepower output. The contract referred to is that of the Quebec Development Co., Isle Maligne Development, where 840,000-hp. vertical plate steel spiral cased turbines are being installed under 110 ft. head.

550,000 HP. CANADIAN DEVELOPMENT

Spiral casings, speed rings, draft tubes and pit liners are also being installed for four additional units, which will give this plant a total capacity of 480,000 hp. when completed. It is expected that the units will develop slightly over 45,000 hp., so that the total capacity of the plant will reach more nearly 550,000 hp. The major parts of the machinery for this installation are being constructed

in the plant of the Canadian Allis-Chalmers Limited. The casings are being built in the Davenport Works, located at Toronto.

Twenty-one contracts were placed in 1923 for the Allis-Chalmers propeller type of turbine developed by Forrest Nagler. In diameter none of these exceed the four which were furnished some time ago for the Green Island Plant of the Ford Motor Co., although several of them, smaller in size, developed greater horsepower than these units, because of the higher head under which they operate.

Attention is also called to the unqiue installation of the Alabama Power Co.'s Mitchell Dam development which contains three 24,000-hp. vertical concrete spiral cased turbines operating under a 70 ft. head. This plant is the one which uses the tailwater suppressor which was designed by O. G. Thurlow of the Alabama Power Co.

70,000-HP. IMPULSE TURBINES CONTEMPLATED

According to the Pelton Water Wheel Co. the size of impulse water wheel units keep increasing and with the

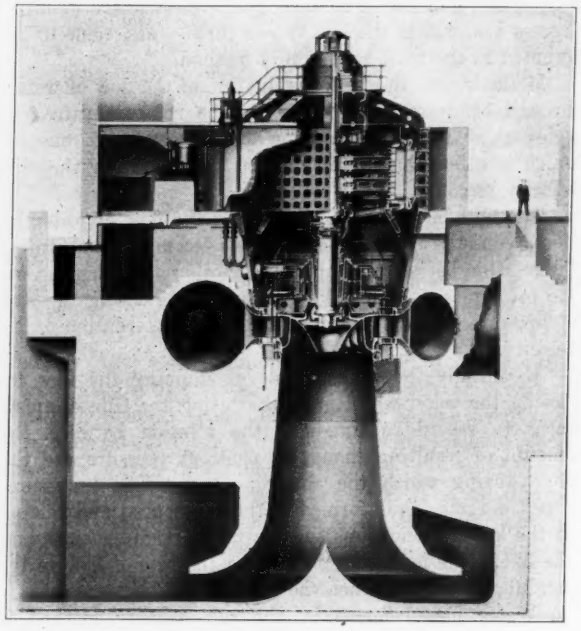


FIG. 4. THE WORLD'S LARGEST PRIME MOVER HAS A ROTATING WEIGHT OF OVER 700,000 LB.

improvements in the designing and control, Pelton wheels of 25,000 to 35,000-hp. are no longer considered unusual In fact there is in contemplation at the present time a Pelton wheel installation on the Pacific Coast in which the individual capacity of the units will be 70,000 hp. The largest single impulse or Pelton wheel installation on the Coast during the past year is that for the Moccasin Creek Plant, Hetch Hetchy water supply for the City of San Francisco, with four 25,000-hp. double overhung units for operation under 1250 ft. effective head.

Rubber seal rings were one of the developments cited by the Pelton organization as of more than usual interest. Former constructions, it will be recalled, have required metal rings at the clearance spaces between the rotating runners and the stationary portions of the casing. Usually these rings have been made in pairs, of which the rotating part is steel and the stationary, bronze. There have been decided limits, however, to the closeness with which these rings could be safely operated. The rubber seal ring seems to be the best solution of the problem to date as it permits the operation of the turbine with little or no clearance between the rotating and stationary parts and yet forms an elastic and well-lubricated surface to accommodate inaccuracies of alignment without danger of tearing or seizing. The water within the turbine casing or from the pipe line is usually all that is necessary to provide proper lubrication.

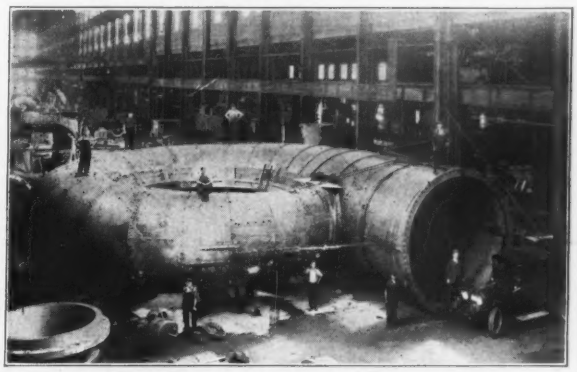


FIG. 5. SPIRAL CASING FOR 70,000-HP. UNIT HAS AN OVERALL DIAMETER OF 50 FT.

One of the Kern River No. 3 units under 810 ft. head is fitted with rubber seal rings at the present time. Rubber seal rings are also being furnished on the Oak Grove plant turbine for operation under 850 ft. head. The three 33,000-hp. turbines for the Pit No. 3 plant for the Pacific Gas & Electric Co., will be fitted with rubber seal rings. This last named plant is the most important installation contracted for on the Pacific Coast during the year 1923 and will be the largest in physical size of any units in the West when completed. The control valves adjacent to the turbine casing have inlets 9 ft. in diameter.

Among the contracts taken by the S. Morgan Smith Co. as outlined in the report are seven units of one size for the Southern Power Co.; four units for their Mountain Island Plant, of 22,700 hp. each, 83 ft. head, 112.5 r.p.m.; three units of this size are for their Dearborn Plant, 72 ft. head, 17,000 hp., and 112.5 r.p.m. The settings of all these units are concrete spiral cases.

Another large installation is that of four units for the Tugalo Development of the Georgia Railway & Power Co., each unit of 22,700 hp., 148.5 ft. head and 171.4 r.p.m. The cast-iron spiral cases have 10 ft. inlet diameters. Another unit for the same company is for their Sawtooth development, 130 ft. head, 8000 hp., 189.5 r.p.m.

Two units for the City of Seattle, at their Gorge Plant, are of 38,800 hp. each, 375 ft. head and 257 r.p.m. These units have cast-steel spiral cases, with direct connected synchronous pressure regulators. The head will temporarily be 275 ft. effective. The same units will be used by changing runners, using the same generators at 257 r.p.m. The rated power at 275 ft. head is 22,700 hp.

This company has also developed new high power runners of unit power values which greatly extends the use of the Francis mixed-flow runners. The high power values

of this runner make possible obtaining large capacities in very small space, compared with older runners.

Pitting of Turbine Runners

Commenting on the subject of pitting of turbine runners, the sub-committee covering this investigation has come to a tentative conclusion that the primary cause of pitting in turbine runners is high draft head resulting in nearly complete vacuums on surfaces of the runners. Pitting occurs where the main stream of water pulls away from the surface and where the vacuum draws from the passing stream a spray of water and oxygen released by

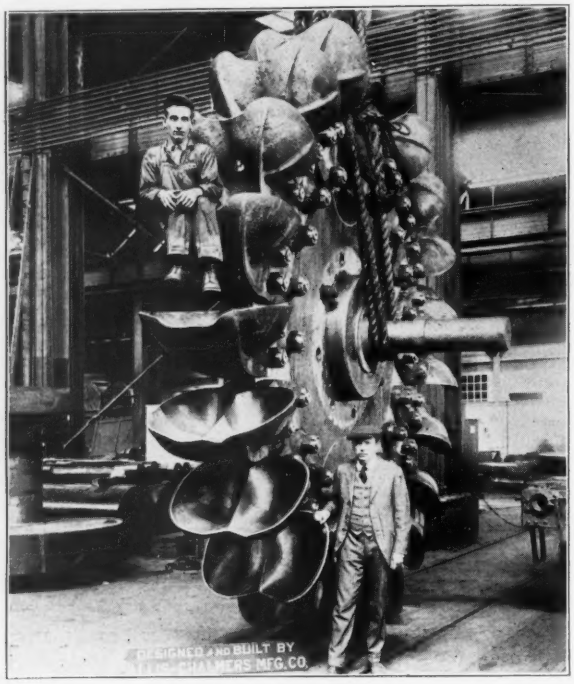


FIG. 6. TWENTY-FIVE-TON WHEEL FOR GREAT WESTERN POWER CO.'S 30,000-HP. UNIT

the draft head. The oxygen becomes highly concentrated because of the violent eddies set up.

Pitting is not confined to any one class or type of turbine runner and does not depend to any great extent on the metal used. Large wheels pit at much lower draft heads than do small wheels.

The principal factors contributing toward the formation of high local vacuums in the runner are given below in the order of their importance: (1) Height above tailwater. (2) Draft due to velocity at the discharge of the runner. (3) Design of the runner as to bucket size, angle, and curvature and as affecting both the distribution of velocities and the local tendency of the stream to pull away from the buckets. (4) Design of the wheel setting, more especially the draft tube.

From an operating standpoint, higher speed, higher head or greater capacity; lowering of tailwater, or improvement of draft tube efficiencies; and finally, that which is most important at high heads, operation at gate openings other than those for the best distribution of velocities, all contribute toward the tendency of a runner to pit.

Pitting may be avoided by a lower wheel setting or by any other method which decreases the draft head. Pitting on existing runners may be minimized by building up the affected areas by the electric arc welding process using a metal that resists corrosion better than the original metal.

Pitted Runners Repaired By Welding

It is stated that the most successful method of repairing pitted turbine runners yet developed appears to be that of electric arc welding. Welding by the oxyacetylene process has not proven entirely satisfactory. The chief difficulty seems to be in getting a uniform heat and in preventing shrinkage cracks.

Only one company reports having welded bronze runners by the oxyacetylene process with any degree of success. This company preheats the runner in a brick enclosure by means of a gas jet, to a uniform cherry red. The welding is then carried on without interruption at this temperature until completed. Finally the runner is allowed to cool gradually. This method was found to be the only one that would avoid fractures.

Repairing of pitted runners by the electric arc welding process has, within the last two or three years, come to be accepted as the most satisfactory method.

Methods used in the determination of the flow of water through conduits is discussed by the sub-committee on water-wheel testing. Two methods are covered, one of which is called the Gibson method and the other the salt velocity method.

The Gibson method of measuring the flow of water in closed conduits is based on Newton's second law governing the relation between the mass and motion of bodies and on the principles (attributed to Joukovsky) relating the rise of pressure in a column of water to the retardation of its velocity.

Essentially the test consists of stopping the flow by closing the water-wheel gates and using the Gibson apparatus to record continuously the relation between the amount of resulting change in penstock pressure and the time during which the change occurs. The "pressure-time" diagram thus formed is then measured and related to the known conditions such as penstock dimensions and the like. The net result determines the rate of flow in the conduit at the time when the gate closure began.

Water measurement by the salt velocity method is based on the fact that salt in solution increases the electrical conductivity of water. A small amount of salt solution is introduced at one section of a conduit and, in traveling with the water past pairs of electrodes placed at one or more other points in the conduit, it causes a change of electric current across the successive electrodes. These changes are recorded graphically by electrical recording instruments. From this chart is thus obtained accurately the time required for the salt to pass between the consecutive points. The volume of the conduit between the same points is accurately determined. The rate of discharge equals that volume divided by the time taken from the chart.

Maintenance Methods in Hydroelectric Plants

In discussing the subject of inspection and maintenance methods for hydroelectric plants, the sub-committee on this subject makes the statement that there is a rather surprising lack of agreement as to the method of scheduling or planning major overhauling or main-

tenance. The one rule on which of course there is agreement is that such work is done so far as possible during the low flow season or period, if any, or if there is no such time then during the season of least load demand.

At one extreme are companies which have no prearranged schedule of overhauling. Annual, semi-annual or monthly inspections are made which do not keep the equipment out of service for more than a short time but a unit is not taken down for thorough overhauling unless and until such inspection or the operation of the unit shows a condition which must be corrected. At the other extreme are companies which lay down schedules of overhauling as well as inspection and adhere to them fairly rigidly (of course no such prearranged schedule can always be carried out exactly as planned). The periodicity of overhaul is changed from time to time as a result of improvements, particularly in the design or construction of the "weakest link," which though small in itself, may require the outage of a whole unit.

Several maintenance systems which are in use are described in the report. That of the Consumers Power Co. is an excellent example of centralized maintenance. The company operates 24 hydroelectric plants. Semi-annual inspections of these plants are made by a regular hydraulic inspector who reports to the main office. This inspector works in conjunction with the division superintendent and the plant foreman. He makes out a complete report on form pages, covering electrical as well as hydraulic equipment and miscellaneous plant conditons, which is bound in a suitable cover. If any important conditions are found that, in the opinion of the inspector, need immediate attention the load dispatcher and division superintendent are notified at once and an "XX" is placed opposite the proper line in the report and also against the subject on the page of contents. If any conditions are noted that tends toward inefficient operation which, in the opinion of the inspector, could be improved upon if certain changes were made, the inspector makes his recommendations and places an "R" opposite the item and also against the subject on the page of contents.

When a unit is taken out of service for inspection it may be essential that the time of outage be kept at a minimum. In order that the inspector may work quickly and systematically and yet not forget any particular item or detail it is desirable that he have with him a list of items which he is to cover. One form may serve as a work sheet from which the inspector's notes are copied on to a permanent record.

Low Pressure Steam for District Heating

SERVICE TO CUSTOMERS ENSURES SUCCESS. BY H. A. WOODWORTH

IN ORDER to connect a satisfactory heating load to a central heating plant, it is necessary to select the class of business that will be satisfied to pay an equitable and adequate rate for 24-hr. service. You must show your customer the most economical method to install and operate his heating system and stand ready at all times to help him effect economies. As long as you keep your customers satisfied you can secure new business that will make the service profitable to the utility company and economical and satisfactory to the user. The usual procedure in obtaining new business is to solicit territory in which the lines extend and offer to furnish an estimate on the approximate cost of heating the buildings.

ESTIMATE RADIATION NEEDED CAREFULLY

Prospective customer's buildings are measured, square feet of exposed glass and exposed wall, together with the cubical contents are obtained and the heat loss is calculated. A sketch of each building is made and special conditions are noted. The total heat loss of each room in B.t.u. is determined and this is divided by the heat given off or emitted by each square foot of radiation (for steam heating, the square foot of direct radiation gives off 250 B.t.u.), thus the total square feet of required radiation is computed from the data obtained.

Sample calculation: To illustrate: Suppose it is desired to compute the amount of steam required to heat a corner room, 14 by 16 by 10 ft., exposed to the north and west, having two unexposed walls, this room being located beneath a ceiled attic and over a properly walled and ceiled basement; the floor being double and the thickness of the outside wall is 12 in.; glass constituting 20 per cent of the total exposure, i. e., equal to 60 sq. ft. With the outside temperature at zero, and the temperature of the room taken at 70 deg., the heat loss from a 12-in. wall is found by experiment to be 21 B.t.u. per sq. ft. of exposure per hour, see Table I, Coefficients for Estimating Direct Radiation, from glass, 77 B.t.u. per hour, while one cubic ft. of air requires 1.4 B.t.u. per hour. The heat losses by

TABLE I. COEFFICIENTS FOR ESTIMATING DIRECT RADIATION

EXPOSURE	Btu per hr. Dif.	Dif. in Temp. Between Room and Outside 65°	70°	75°	80°	85°	90°
Single Glass, Loose	1.50	97.5	105.0	112.5	120.	127.5	135.0
Single Glass, Medium	1.35	87.8	94.5	101.3	108.	114.8	121.5
Single Glass, Tight	1.20	68.0	72.0	90.0	96.0	102.0	108.0
Double Glass, Storm	.60	39.0	42.0	45.0	48.0	51.0	54.0
Vault Glass, Sidewalk	1.50	97.5	105.0	112.5	120.	127.5	135.0
Single Skylight	1.08	70.2	75.6	81.0	86.4	91.8	97.2
Double Skylight	.60	39.0	42.0	45.0	48.0	51.0	54.0
Good Door, 1/2 Glass	.69	44.9	48.3	51.8	55.2	58.7	62.1
Good Door, Solid	.48	31.2	33.6	36.0	38.4	40.8	43.2
Poor Frame NW	.45	29.3	31.5	33.8	36.0	38.3	40.5
Average NW	.42	27.3	29.4	31.5	33.6	35.7	37.8
Back Plastered Frame NW	.33	21.5	23.1	24.8	26.4	28.0	29.7
8" Brick " NW	.39	25.4	27.3	29.3	31.2	33.2	35.1
12" Brick " NW	.30	19.5	21.0	22.5	24.0	25.5	27.0
16" Brick " NW	.24	15.6	16.8	18.0	19.2	20.4	21.6
Ceiling, Floor above	.30	19.5	21.0	22.5	24.0	25.5	27.0
Ceiling, No floor "	.60	39.0	42.0	45.0	48.0	51.0	54.0
Floor, Plaster below	.15	9.8	10.5	11.3	12.0	12.8	13.5
Floor, No " "	.30	20.0	21.0	23.0	24.0	25.5	27.0
Partition, Plastered	.20	13.0	14.0	15.0	17.0	17.0	18.0
CUBIC SPACE							
1/2 change, pr. hr.	.009	.59	.64	.68	.72	.77	.82
1 change, per hour	.018	1.18	1.4	1.42	1.45	1.55	1.66
1½ " " "	.027	1.77	1.91	2.05	2.18	2.32	2.45
2 " " "	.036	2.36	2.55	2.73	2.91	3.09	3.27
3 " " "	.055	3.55	3.82	4.09	4.36	4.64	4.91
4 " " "	.073	4.73	5.09	5.45	5.82	6.18	6.55

NOTE: Multiply Exposure or space by coefficient corresponding to desired difference in temperature and divide result by;

250 for Low Pressure Steam
230 for Vapor or Atmospheric Steam
170 for Hot Water - Temp. 180 deg. at 0 deg.

radiation are: Through the wall, $240 \times 21 = 5040$ B.t.u.; by radiation through the windows, $60 \times 77 = 4620$ B.t.u.; by air leakage from the room, $14 \times 16 \times 10 \times 1.4 = 3136$ B.t.u.; making a total heat loss of $5040 + 4620 + 3136 = 12{,}796$ B.t.u. Then, 12,796 divided by 250 equals 51.2 sq. ft. of radiation required.

It is customary in examples such as the above to take

one change of air per hour on account of air leakage through the walls, doors and windows. Under average conditions, that is sufficient but, in extreme cases, two changes or more are allowed. This process takes the place of using exposure factors. In theatres or auditoriums, the necessary changes of air are determined by the cubic contents of the rooms and the seating capacity of the rooms; therefore the above rule is flexible enough to take care of various conditions. The process is followed out for each room and the total required steam radiation for the building is calculated. The required amount of radiation is estimated upon a basis of heating to 70 deg. F. with an outside temperature of 10 deg. below zero. Many factors enter into the estimate. The kind of walls, thickness and kind of windows, the kind of material used, the roof and floor exposure, all must be given due consideration. The writer has made a check of the German heat loss rule, the Austrian heat loss rule and the rules of the most competent American heating engineers. These rules all check out

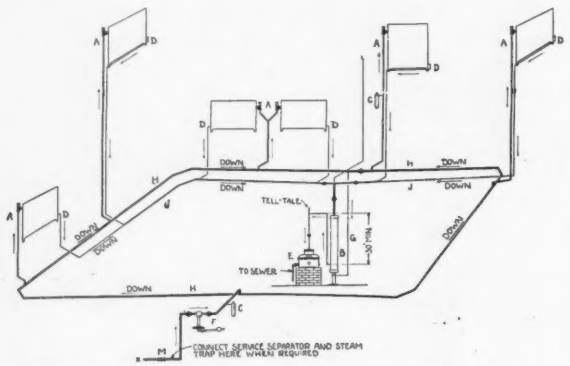


FIG. 1. MODERN INSTALLATION FOR HEATING FROM CENTRAL SYSTEM

practically the same. The method that the writer has found most flexible is embodied in Table I.

Advantages of District Heating

Having the necessary data as to the required radiation of the prospective customer's building, the solicitor estimates the cost of heating based on a meter rate. The argument which secures the prospective customer is that central heat makes his place more desirable inasmuch as he can promise his tenants heat 24 hr. a day and nine heating months out of the year. At the same time, his temperature is automatically controlled and maintained at 70 deg. and the heat is delivered to his building free from ashes, soot, smoke or hazards and other inconveniences that accompany heat from an isolated plant. This argument of perfect service wins the business for the heating company. Once the business is legitimately won, the isolated plant is forgotten but winning the business unfairly is what causes failure of many district heating plants.

Some of the many advantages of district heating as compared with isolated plant heating are: No ashes to be removed; no boiler to be installed; no depreciation of apparatus; increased value of real estate; no fires to build and look after; abatement of the smoke nuisance; easier to secure and maintain help; increased salability of property; time saved for both servants and householders; reduction of fire risk, consequently of insurance; large saving in the cost of repairs to heating apparatus; supply of heat at all hours every day of the heating season; much more satisfactory service than individual heating affords; life and health not jeopardized by coal gas and boiler explosions; increased cleanliness due to the absence of coal, smoke and ashes about building; simple means always at hand for heating water for laundry, baths and other purposes; stores, offices and residences more rentable and always occupied in preference to others; increased amount of available space in buildings due to the absence of boilers, coal bins, ash piles, etc.; cost of heating is divided into as many bills as there are months in which the service is rendered and payments are made after the heat is used, instead of paying for the coal in advance of the heating season.

Customer's Installations

Attention is now turning to running services to new business. After the heating contract is signed, the order is issued to run service and it is laid to the consumer's premises. The company usually charges at cost for laying this line of pipe from the property line to the basement of the consumer but retains the right to lock the entrance valve in case the contract is violated, or bills are not paid. Inside the basement, the building equipment begins. This work is usually done by the heating contractor but must meet the requirements of the rigid specifications set forth by the heating company. The cost is a great deal less in installing central station heating than for a private steam plant as the cost of boilers and extra fittings is saved. An automatic temperature regulator, a pressure valve and suitable steam traps are installed. All exposed piping in unused rooms or basements is covered with an efficient insulating material. The required radiation as estimated by the heating company must be installed and the complete job must pass the inspection of the superintendent of the district heating company before steam will be furnished a consumer. Each installation must have a sealed meter installed and the equipment must be tested, to the complete satisfaction of the customer and the heating company alike, before the contractor is given a letter of acceptance.

Atmospheric Steam Heating

Figure 1 brings out the most recent practice in district heating. This is a two-pipe system using steam, with a graduated valve on the supply end of the radiator and a union ell on the return end, known as an atmospheric or vapor system. Steam pressure is reduced by means of a suitable regulating valve placed on the supply line, the pressure carried on the system being usually ½ lb. Hot water type radiation must be used in these installations and the connections must be made at the top on the supply end and at the bottom on the return end, the supply to the radiator being regulated by a specially constructed graduated valve. This valve is so designed that it is possible to supply steam to any portion of the radiator up to approximately 90 per cent, the remaining portion acting as a hot water radiator. The greater part of the available heat units are thus utilized so that, when the condensation passes from the radiation to the sewer, it is at a low temperature as compared with the discharge from the one-pipe, low-pressure system. The customer has complete control over his heating system, as any portion of the radiator may be heated to suit the outside changes in temperature. This system saves on an average of 25 per cent in fuel over any other system that might be installed;

at the same time, it gives vacuum heating results without the necessity of purchasing a vacuum pump and eliminates the attention that must be given a vacuum system. Other advantages are minimum attention and pressure requirements, perfect control and quick results, greater simplicity and flexibility of system and absence of air valves with their disagreeable odors. We have the combined advantages of both steam and hot-water heating with the undesirable features eliminated.

Having secured the business the next and most important thing to do is to keep it. In order to do this, the company must give perfect, or as near perfect, service as possible and, in case of any interruptions in service, immediate response to complaints and courteous treatment must prevail.

The heating company should have men whose duties are to make inspections and collect all necessary data on consumers' installations. This information should be recorded and filed in the office for future reference. In new installations, in case of violations of specifications the consumer should be notified by letter. If the inspector sees any means for improving the efficiency of the system and thereby reducing the steam consumption, he should explain the changes necessary to bring about the desired results. In this way he perfects the consumers' heating system by suggesting remedies, thereby saving money for the consumer and steam for the public service company. The result is that the company has a contented customer who is a future booster for city heat.

How to Operate a Heating System

The company's service valve will be opened by the company when the service begins. If there is a house valve on the system, it should be used to turn steam on and off and the service valves should be left open. Open the house valve wide; a valve partly open soon wears out and no economy can be effected by leaving it partly open. Next, see that the return valve, located just ahead of the trap, is open and then turn on the radiators.

When less heat is required, turn off the radiators in the warm rooms rather than open the windows. When no heat is required in any of the rooms, shut the steam entirely off the building by means of the house valve. The valves ordinarily used with thermostats do not close tight and should not be depended upon to shut the steam off completely.

In Case of Trouble

If the radiators do not become warm soon after the radiator valves are opened, make sure that the service valve and the house valve are open. These valves open when turned counter clockwise, viewed from the top. See that the return valve is open. If the radiators do not become warm in a reasonable time, notify the company. The company maintains a 24-hr. trouble service to take care of such cases but it finds cases, daily, where failure to obtain heat is due simply to some employe or member of the family having closed the house or service valve.

Air valves on radiators should need no adjustment after they are once properly set. If a radiator does not fill with steam and the trouble seems to be in the air valve, notify the company.

If pounding occurs in the pipes, see that the return valve is open. If the noise still continues, the trap is probably not working properly and the company should be notified. The company repairs traps and replaces diaphragms in customers' reducing valves, charging the customer for the material only. Trap valves and seats are replaced without charge.

If, on extremely cold days, the radiators are all hot and the building cannot be brought to a comfortable temperature, the trouble is probably due to insufficient or wrongly located radiation.

The Heating System

Steam, on entering the consumer's heating system, usually passes through a pressure-reducing valve whose function is to maintain a reduced and constant pressure on the system. A pressure from 1 to 2 lb. is sufficient. The steam passes into the radiators where it is condensed and gives up the heat which it absorbed from the coal when generated. The water of condensation drains from

FIG. 2. THIS BALANCED BUCKET METER MEASURES THE STEAM USED BY THE CONSUMER

the radiators and into the trap, which holds back the steam and allows only water to be discharged. The water then passes through the meter, where it is weighed and the weight registered. The condensation represents the amount of steam actually used and is the basis on which the consumer is charged.

Heat which is given up by the steam in the radiators is used in several ways: It warms the furniture in the rooms, the floors, walls and ceilings. It warms the air which leaks into the building through the walls and cracks around the windows and doors and also warms any air that is admitted for ventilation. It replaces the heat which is radiated through the windows, walls, floors, etc.

In the old time heating system, the customer paid such a low rate for heat that the heat furnished was insufficient. So the customer demanded "uptown heating service" and the heating company asked an equitable and adequate rate and a change from the flat rate to a meter basis of charge. A meter was developed in 1890 that could be used to measure this condensation from the customers' radiation in pounds and the rates were based on a charge per thousand pounds of steam. The meter used is a balanced bucket illustrated in Fig. 2, and all heating companies are now operated on a meter basis. The reasons for a change from a flat rate to a meter basis are best shown by the following letter written to the customers of a company then on flat rate but which now sells on a meter basis only:

"Our heating plant was installed with the idea of operation only on a meter basis but we were unfortunate in selecting a new meter that worked well on paper but not at all in practice. Hence, we were compelled to resort to flat rates, based upon the estimate of proper meter service as near as we could approximate. The result has been that we are forced to return to our original meter plans. A flat rate is nothing short of criminal; it makes a robber of the consumer and the operator a murderer at heart.

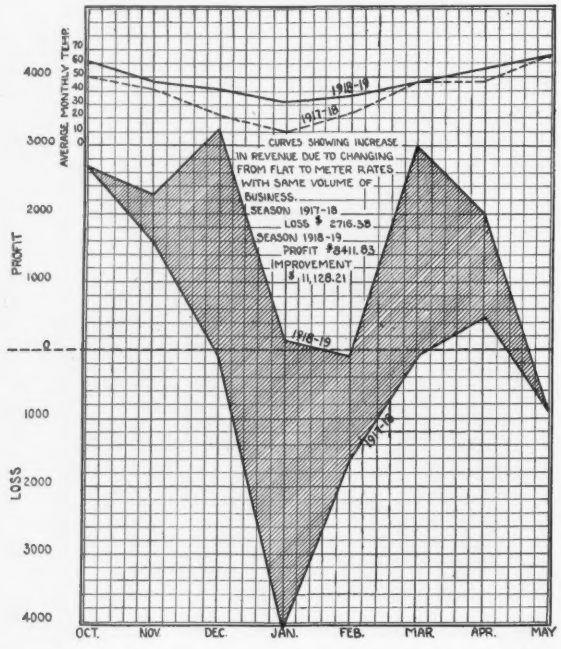


FIG. 3. LOSSES FOLLOW FROM FLAT RATES AND PROFITS FROM METER RATES

"Rates named in our franchise are intended to be reasonable and, in spite of the fact that we have not tried them to any great extent, we believe they are. Meters will be placed on all consumers, though some are yet on flat rate contracts, so that we may obtain data and information. Rates were based upon 36 yr. of actual weather conditions, 70 deg. of heat and normal prices of coal. The same schedule of rates has proved satisfactory in Indiana, Illinois and Ohio communities which are surrounded by better and cheaper coal than we get here.

"Each job is governed by thermostatic control and adjustment will regulate the heat within 1 or 2 deg. It is not at all difficult to understand and it is our wish to give each consumer all the instruction we can but every service has conditions and needs differing from the others and is a problem by itself. The consumer will have to study his individual needs and let us help and learn with him the best method of operation. Our responsibility ceases with the heat at the valve but our desire and interest are to give the best and most efficient service.

"It is unfortunate that there has ever been the evil of flat rates for it is conducive only to lack of care and attention, which are absolutely necessary under the operation of the meter system. It will take a little time to get the habit of regulating the heat by radiator and thermostat, rather than by opening doors and windows.

"Now a word as to the meter we have adopted: We have investigated this meter for 2 yr. and know that it will work accurately and continuously. We wish to emphasize the continuous performance for we must have our patrons appreciate that fact. It will register only the condensation that goes through it and condensation only takes place when the heat is turned on. If there is extravagance in the use of heat, the bills will be proportionately big but if the heat is used legitimately they will be no larger than they should be. It must be borne in mind that, as it is so easy to have heat under this system, you will use much more than you did under the old troublesome methods of supply. It will take effort and attention to prevent this luxurious necessity from becoming an extravagant luxury; however, we will guarantee to furnish the *same amount* of heat used under old conditions for less money than it formerly cost. It is a popular idea that the cost of heat is the sum paid for coal, when as a matter of fact the fuel is only 65 per cent of the whole. We ask you to watch this meter closely for it will tell the story; we expect to do the same and will have at the office a meter tester that anyone can readily understand.

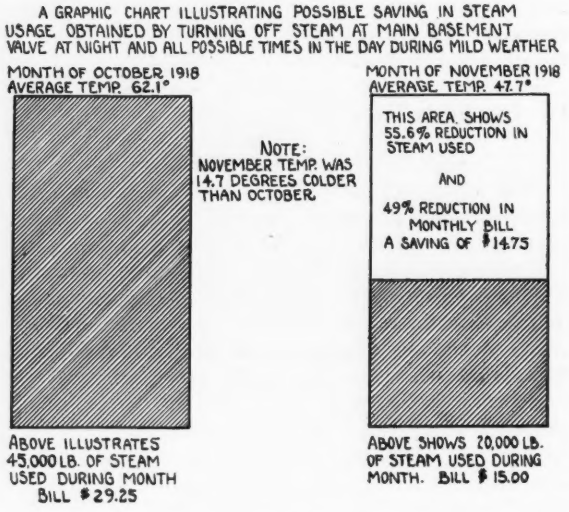

A GRAPHIC CHART ILLUSTRATING POSSIBLE SAVING IN STEAM USAGE OBTAINED BY TURNING OFF STEAM AT MAIN BASEMENT VALVE AT NIGHT AND ALL POSSIBLE TIMES IN THE DAY DURING MILD WEATHER
MONTH OF OCTOBER 1918
AVERAGE TEMP. 62.1°
MONTH OF NOVEMBER 1918
AVERAGE TEMP. 47.7°
NOTE:
NOVEMBER TEMP. WAS 14.7 DEGREES COLDER THAN OCTOBER.
THIS AREA SHOWS 55.6% REDUCTION IN STEAM USED
AND
49% REDUCTION IN MONTHLY BILL
A SAVING OF $14.75
ABOVE ILLUSTRATES 45,000 LB. OF STEAM USED DURING MONTH
BILL $29.25
ABOVE SHOWS 20,000 LB. OF STEAM USED DURING MONTH. BILL $15.00

FIG. 4. TURNING OFF STEAM AT THE MAIN HOUSE VALVE WHEN NO HEAT IS WANTED REDUCES HEATING BILLS

"There are many things that will tend either to increase your bills, or to make them reasonable and satisfactory to you and we make some suggestions to that end: All supply pipes should be covered with asbestos. Basements must be made tight. A small hole, or crack around a window or door, on a cold, windy day lets in a regular cyclone of cold and wind. This is most important. Don't forget it.

"Unused rooms in which heat is not often needed should have the radiators shut off and doors to communicating apartments closed. If the door is left open the rest of the radiation will be called upon to work overtime; especially is this so if the room is on the second story. Sleeping rooms where heat is not desired should have the door closed and radiator shut off.

"The thermostat should be located to control the greatest portion of the house possible. On retiring at

night, or leaving the house for a length of time, the thermostat should be turned back to 50 to 60 deg. Merchants should observe this particularly. This will prevent the house from getting stone cold, a bad policy. If there is a portion of the house that is desired to be heated about the same temperature continuously, the radiators should be properly set and the control be made entirely by the thermostat.

"Two-thirds of the entire consumption of fuel, or steam is ordinarily used in the 60 days between Dec. 15 and Feb. 15. Our rates are based accordingly and it will take the entire season's bill to determine the whole amount.

"Houses are so differently constructed and the needs and ideas of the occupants vary so materially, that the same number of rooms or the same amount of radiation is no criterion in determining the amount of heat that may be used during the season. This is one of several considerations that convinced us of the futility and impossibility of flat rates. Old systems that have been connected to the central plant will not be as efficient as the new ones and will require more care and attention to obtain satisfactory results.

"Our experience has demonstrated to us, conclusively, that we cannot operate the plant other than on a meter basis. We know this will not be the wish of some of our customers but we know, also, that not one will question the justice of this plan of operation. Hence, we ask the hearty cooperation of our consumers and we will guarantee that, if one-hundredth part of the labor is put forth in the management of this system that was necessary in the production of heat by any of the old methods, we will satisfy the majority of our patrons in service and cost. Come to us with your troubles and let us jointly get at the best way of operating your own plant. Your neighbor has troubles of his own and what may be the cause of his will not benefit you at all. It is our business and wish to help solve all difficulties." Mexico Power Company.

The foregoing company changed to a 100 per cent meter basis. It went from a loss to a gain immediately and has been on an earning basis ever since.

Another case of a central exhaust heating system changing to a meter rate is as follows: For 20 yr. a city of 30,000 population had operated on a flat rate basis with a deficit each year. The system of selling was changed from flat rate to meter rate without the loss of a customer. The first year the company made money from its heating business operations. Figure 3 is a comparison of the revenue on a flat rate and on the first year meter rate.

The first few months on a meter is usually wasteful. The writer refers you to Fig. 4 from records of a jewelry store showing $29.25 worth of steam used on a meter basis in October, which dissatisfied the customer to such an extent that he threatened to discontinue service. The heating company, however, showed him how to regulate his steam and the bill for the following month, November, was but $15. Had it continued on the same basis as in October, it would have been $73. The utility made a satisfied customer and did not lose a customer due to the change from the flat rate to a meter rate basis of charge.

Demand Soon Outruns Supply

Meter readings for the heating season can usually be ascertained approximately as follows:

5 per cent of the total yearly bill for months of October and April.

15 per cent of the total yearly bill for months of November and March.

18 per cent of the total yearly bill for months of December and February.

24 per cent of the total yearly bill for month of January.

Many people ask, "Is there a demand for Central Station Heating?" In every city the lines and plants are fully loaded within 5 yr. from the time district heating is installed. The utility company should lay its lines out to reach the best business and residence section, as the business in cities has changed from one street to another, due to the steam lines being placed without this consideration. The locations of new school houses have been changed so that the building might be heated by district steam. Following is a letter citing a specific example of this preference:

Huntington, Ind., July 15, 1919.

Mr. Charles Davis, Public Service Company,
Rochester, Indiana.

My dear Mr. Davis:

While Mr. H. A. Woodworth of Chicago was in our office several days ago, he inquired relative to the attitude of the local school board in regard to steam heat and I advised him that the question of being able to obtain Central Station steam was the deciding factor relative to the location of the new High School Building. The School Board absolutely refused to consider a site where it would be impossible for them to secure Central Station steam. They also have it in every school and public building in this city, even the Christian Science Church has been begging us for service for its proposed new building.

With kindest personal regards, I am,

Yours very truly,

THE HUNTINGTON LIGHT & FUEL CO.,
(Signed) Frank Townsend,
Secretary.

cc to Mr. Woodworth

TABLE II. COMPARATIVE STEAM CONSUMPTION OF OFFICE BUILDINGS FOR THE HEATING SEASON FROM OCTOBER 1 TO MAY 1

Building "A" - Single pipe system vacuum air line
Building "B" - Two pipe system vacuum.
Building "C" - Same as bldg. "A" with thermostatic control

	Bldg. "A"		Bldg. "B"		Bldg. "C"	
Cu.ft.contents	4,415,104		3,794,430		2,287,758	
Sq.ft.dir.radiation	40,005		48,924		29,125	
Sq.ft.indir.radiation	9,256		5,670		2,484	
Sq.ft.equiv.radiation	53,421		54,944		44,051	
Sq.ft.equiv.rad.per cu.ft.contents	0.0180		0.0179		0.0198	
Season	'19 - '20		'19 - '20		'19 - '20	
Ave.Temperature	36°	43°	36°	43°	36°	43°
Lb.steam per Htg. Season only	52,094,000	18,816,300	35,932,745	27,742,095	17,218,465	12,872,800
Lb.steam per sq.ft. radiation	688	219	539	427	393	279
Lb.steam per season per cu.ft. contents	11.8	4.1	9.8	7.3	7.4	5.8
Lb.steam per sq.ft. radiation per day per degree below 65 deg.-	0.100	0.046	0.086	0.090	0.068	0,059
Lb.steam per 100 cu. ft. contents per day per deg.below 65 deg.	0.169	0.087	0.148	0.154	0.119	0.111

Check Customers' Bills and Help Reduce Them

To secure central station heat customers is comparatively easy, much of the business coming unsolicited but to keep them satisfied is the management's most important task.

Of the 500 central heating plants in the United States, the most successful are those which make a special effort to keep their customers' heat bills to a minimum. The best method of checking the customers' steam consumption is as follows:

Customers' meters are read four times a month, the periods being as nearly equal as possible. The steam consumption for the period is then put on a 30-day basis which is then divided by the sq. ft. of equivalent to direct required radiation and the degree of temperature difference for the period, the quotient being the constant for this particular building. This constant should remain the same for the weekly periods, provided the meter is registering correctly and the same method of regulation is carried out each period.

Data taken from a page of the meter book, showing the reading of a meter installed in a four-story department store having 15,451 sq. ft. of equivalent to direct radiation, will serve to show how this method works. The meter page shows the readings for the entire season of 1921 and 1922.

Taking the period from Nov. 22 to Nov. 29 in which there were seven days with an average outside temperature of 39 deg. or a temperature difference of 33 deg., and a steam consumption of 177,000 lb.

The estimated consumption for the month would be:
30 days ÷ 7 days (in period) × 177,000 lb. = 760,000 lb.
760,000 lb. ÷ 15,451 (E. D. Req. Sq. Ft.) = 49 lb.
49 lb. ÷ 33 deg. (Temp. Diff. for 7 days' period) = 1.48, say 1.5, the Period Constant.

Taking the following period from Nov. 29 to Dec. 6 and using the same procedure:
Number of days, 7; temperature diff., 32 deg.; steam consumption, 169,000 lb.; estimated monthly consumption = 30 ÷ 7 × 169,000 = 724,000 lb.; estimated monthly consumption per E. D. Req. Rad. = 742,000 ÷ 15,451 = 47 lb.; period constant equals 47 ÷ 32 = 1.47.

You will note that for the above periods the constant varied but little and the meter page showed the extreme variation was only 0.3 from Nov. 11 to March 8, showing that the meter was operating correctly and the regulation was good. If this constant had dropped to 0.8 or 0.9, the manager of the department should have investigated to find the cause of the decreased registration. If the constant had increased to around 2.4 or 2.5, he should again have investigated and, if the inspector reported the meter working properly but found the doors and windows open with the steam on, the manager of the heating department should have notified the customer either by letter or personal call and advised him of methods which would enable him to reduce his steam consumption and thereby his bill.

While the finding of this constant appears to be laborious, it is not as bad as it looks. In the company where this method is used, all the calculations are made by a girl with the slide rule and she subtracts the meter readings and figures the constants for 500 customers in a day's time.

To educate customers as to the most efficient heating system to use, it is advisable to show them records comparing various types of heating installations so that old as well as prospective customers can adopt the most efficient system of heating.

At the close of each heating season, the records of the various types of heating systems are recapitulated. The results of the season's operations are compiled and given to the various customers. Table II shows the comparative steam consumptions of office buildings.

Given a central heating plant properly installed, economical in operation, with equitable and adequate rates, the degree of success of the plant depends on efficient management and not on a superintendent at "the least possible cost" because the revenue per dollar invested is high and calls for the best possible direction for mechanical and financial success.

Combustion Control Based on CO_2 in Gas

VARIATIONS IN CO_2 OPERATE RHEOSTAT CONTROLLING SPEED OF FAN MOTOR. BY GEORGE E. GASTER

THIS SYSTEM has for its object the providing of a means by which the draft of a furnace is made to respond accurately and continuously to the composition of the products of combustion with respects to the CO_2 content thereof, whereby the combustion may be regulated automatically to effect maximum efficiency of fuel consumption.

Figure 1 is a diagrammatic view showing the connected elements of the system. Figure 2 is a vertical section, partly in elevation, of a liquid rheostat employed to control the electrically operated draft device of the system.

In Fig. 1 the system is shown applied to the regulation of a furnace for boilers. Numeral 10 designates the furnace and 11 a pipe for conducting a portion of the flue gases to a CO_2 responsive device. The CO_2 responsive device which I prefer to use is one in which a pressure, suction or a pressure difference is continuously produced varying with the per cent CO_2.

The high and low pressures of the CO_2 recorder are connected by the pipes 12 and 13 respectively, to a liquid rheostat 14, the construction of which is shown by Fig. 2. This rheostat is adapted to be inserted in the field circuit of a shunt motor 15, so as automatically to vary the speed of the motor proportionately to the variations of the CO_2 content of the flue gases. The motor has a driving connection with a blower 16 which supplies the furnace draft. The motor starting switch is designated by 17 and 18 designates a switch by means of which the automatically operated rheostat may be cut out so as to permit manual control of the draft when desired by the rheostat 19.

Figure 2 illustrates the specific construction of the rheostat. It comprises an air tight metallic casing, 20, in which is placed an inverted cup member, 22, the lower end of which is open and which has its upper end closed by a metallic plate, 24. The plate, 24, has formed therewith a tubular member, 25, of relatively small cross section projecting downwardly a substantial distance in the cylindrical interior of member 21. The lower end, 26, of tubular member 25 is closed and the upper end thereof opens through a central aperture in plate 24.

Secured in an insulating bushing, 28, which is mounted in a central aperture formed in the cover of casing 20, is conducting rod, 27. Rod 27 projects down into the tubular member, 25, and the latter holds a sufficient quantity of mercury to form a good contact with rod 27 at all positions of cup 22. The body, 29, of the cup member is composed of suitable insulating material

and a complete circular series of resistance wires, 30, are supported in the inverted cup member, 22. The upper ends of these wires are connected to the metallic plate, 24, and the lower ends thereof define a spiral, the wires progressively decreasing in length from the wire of maximum length to a wire of minimum length, as clearly shown by the drawing. The annular space between the inner walls of casing, 20, and the periphery of member, 21, contains a suitable quantity of mercury and a covering layer of transformer oil.

High pressure pipe, 12, from the CO_2 recorder communicates with the interior of member 21, while the low pressure pipe 13 opens into the upper part of casing 20. One terminal of the rheostat is a binding screw, 32, which is one of the screws for fastening the cover of casing 20, and the other terminal is a binding screw, 33, which is screwed in the upper end of rod 27.

The system described above operates in substantially the following manner: The switch 18 and the starting switch 17 being in closed position and the rheostat switch 19 being open, the motor is rotating at a certain speed depending upon the position of the cup, 22, of the rheostat

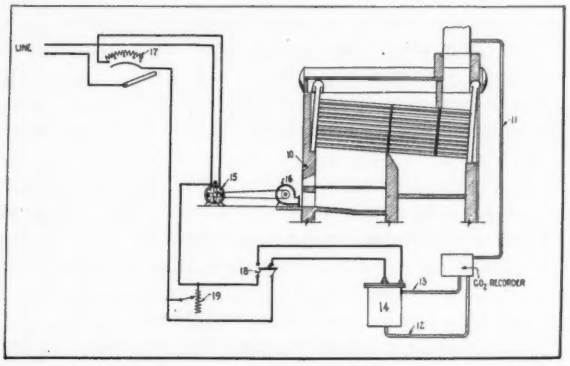


FIG. 1. FIELD CIRCUIT OF FAN MOTOR CONTAINS RHEOSTAT OPERATED BY CHANGES IN FLUE GAS ANALYSIS

with respect to the mercury therein, such position determining the resistance in the field circuit of the motor. The CO_2 recorder, as has been pointed out, is continuously responsive to the per cent content of CO_2 in the flue gas and continuously produces a difference of pressure in the rheostat proportional thereto.

Now if the CO_2 content in the flue gas falls below a certain pre-determined value, the difference between the pressures inside and outside the cup, 22, will decrease. Consequently the level of mercury in the cup will rise and that outside the cup will fall and the cup itself will move down with respect to a stationary point. This downward movement of the cup and upward movement of the mercury level in the cup will cause more of the resistance wires to project into the mercury, thereby lowering the resistance of the motor field circuit and causing more current to flow through the field coils, lowering the speed of the motor. The draft will thus be reduced and the CO_2 content of the flue gas will increase to the normal pre-determined value.

When the per cent of CO_2 rises above the pre-determined value, the difference of pressure in the rheostat increase, the level of mercury in the cup, 22, falling and that outside the cup rising and the cup itself moving upward with respect to a stationary point. This upward movement of the cup and downward movement of the mercury level therein will cause a wire or a number of wires, as the case may be, to be withdrawn from the mercury, which will increase the resistance in the motor field circuit and cause the motor and fan to speed up. More air will be supplied to the furnace and consequently the CO_2 content of the flue gas will decrease to the pre-determined value.

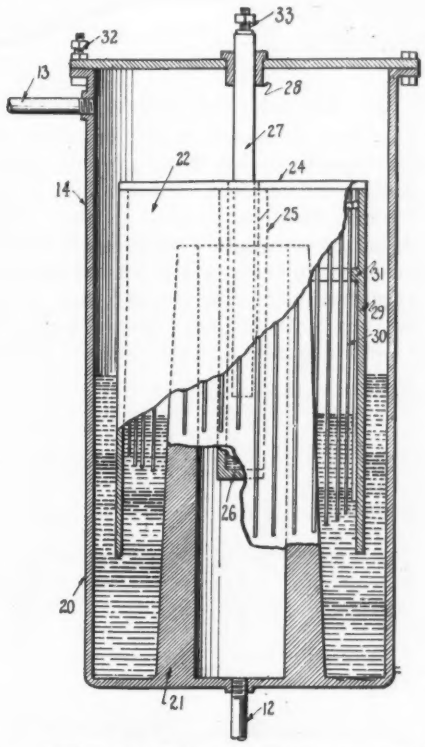
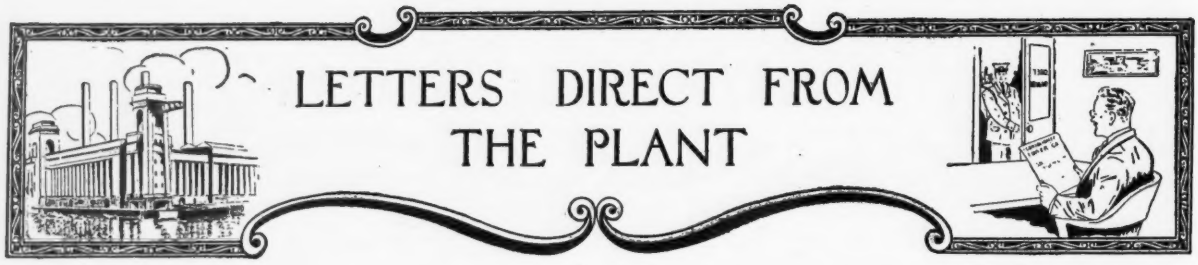


FIG. 2. RHEOSTAT VARIES POSITION WITH CHANGES IN CO_2 IN GASES

In order to adjust the system to different conditions, I prefer to employ an auxiliary or adjusting rheostat. By means of this rheostat, the system can be easily adjusted manually to suit any condition. For example, suppose that the system is maintaining the CO_2 at about 11 per cent and it is desired to maintain it at about 14 per cent. To do this it is necessary only to adjust the auxiliary rheostat in a direction to increase the fixed resistance in the field circuit of the motor, thus causing the motor to operate at lower speeds with respect to given positions of the automatic rheostat, decreasing the air supply and raising the CO_2 per cent to the desired pre-determined value. After being adjusted for any given conditions, the system should operate without further attention.

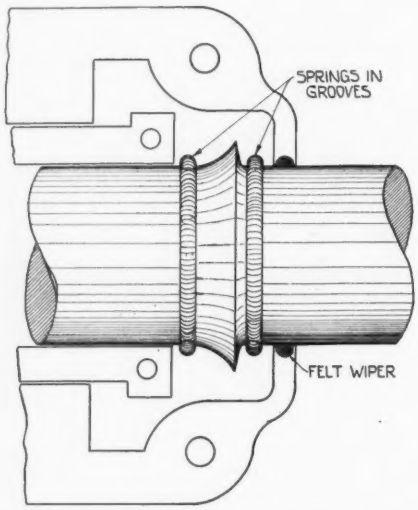
Perhaps there may be some doubt as to whether a CO_2 recorder of the type required for this system will give a sufficient differential to operate the rheostat shown in Fig. 2. This problem was carefully investigated in the case of one well known CO_2 recorder and to a lesser extent with others, and in each instant the change in pressure difference with a change in CO_2 was found to be sufficient for the reliable operating of the system.

This article attempts to describe only one method of application of the principles involved. Many variations are possible by a modification of the design of the rheostat shown in Fig. 2. Various types of motors may be used to drive the fan.



Novel Oil Thrower Proves Effective

I NOTE that in many engine rooms difficulties present themselves in preventing oil from creeping along the shafts of engines and turbines. The oil discs of various types which manufacturers provide on their machines fail to throw off the oil back into the reservoir and a great amount of it creeps to the wipers which become saturated and oil is continually creeping out and over the engine casting presenting a constant nuisance and waste. I have solved this problem by placing a spring $\frac{3}{16}$-in. in diameter



COILED SPRING IN A GROOVE ON THE JOURNAL PREVENTS THE SPREADING OF OIL

in grooves on either side of the oil disk, hooking the ends together around the shaft and leaving a clearance of $\frac{1}{32}$-in. between each coil of the spring. The centrifugal force acting on the oil adhering to the surfaces of each of the numerous coils of the spring divides the oil film into minute particles, throws it all off and prevents any further creeping, thereby eliminating any further saturation of the wiper.

If there are no grooves in the shaft a recess for the spring can easily be made by taking off the upper half of the bearing and fastening a cutting tool to one of the bearing studs and turning the machine over slowly either by hand or with steam. W. L. POWELL.

Eliminating the Licensed Fireman

REPLYING TO Mr. Cultra's comment on page 565 of the May 1 issue on my letter in the April 15 issue, page 449, entitled, "Doing Away with Licensed Firemen and Engineers," I wish to say that I do and did understand the Massachusetts Engineers' and Firemen's License Laws; my contention is that the law is at fault as far as it applies to boilers for industrial purposes.

The stationary engineer of today is a man trained in the profession of steam engineering; his daily work, 365 days a year, is to operate and maintain efficiently and safely the power plant, and above all else to eliminate the loss of life and destruction of property.

In case of an accident, causing injuries, if due to carelessness or neglect on the part of the engineer or firemen, his license can be revoked to prevent him from causing another accident. In the case of a plant operated by a man without a license no such recourse is possible.

The steam plant must operate with safety at all times. How can a man who does not understand the construction, care and operation of steam boilers and the various necessary boiler appliances maintain a plant in a safe condition at all times?

To my mind a boiler carrying 15 lb. per sq. in. pressure is not safe at any time where an unskilled operator is hired to operate, care for and maintain it.

Can you bag a horizontal return tubular boiler carrying 15 lb. pressure? Could this occurrence prove fatal? Would the unlicensed man know what would cause a bag on a boiler? Does he know how to prevent it? Does he understand the possible danger a bag may develop?

It is difficult for me to understand how the owner of a power plant can hire cheap labor in his plant.

They seem to forget entirely that firing a boiler is a much more difficult job than shoveling coal from a coal car and that a skilled fireman can save two or three times his wages in coal.

Springfield, Mass. ERNEST E. CLARK.

Grates for Burning Anthracite

IN POWER PLANT ENGINEERING for June 1, Mr. Waheman calls the statement, "It is well recognized that it is necessary to use pinhole grates or the equivalent for burning small anthracite efficiently at high rates of combustion"—startling—and then goes on to prove it by citing his experience with a mixture of soft coal and anthracite dust, which is an entirely different matter. The characteristics of a fire with such a mixture are entirely those of a soft coal fire as the coke holds up and separates the anthracite particles so that the effect is largely as if the soft coal coked up into a mass, hard and dense in spots.

It makes little difference about the consistency of the mixture as fired, what counts is the structure of the fuel bed after the volatile matter has been driven off and the fixed carbon remaining on the grates heated up to redness. It will usually be found with such mixtures that unless the rate of combustion is rather slow much unburned

carbon from the anthracite dust will be found in the ashpit refuse. This is particularly noticeable in trying to burn the mixture on stokers with a progressive feed, particularly the underfeeds, as the soft coal coke seems to burn out much more quickly and leave the harder anthracite behind.

Regarding the pinhole grate question, I had an interesting experience lately in visiting a plant using forced draft chain grate stokers of two types now being used for burning small anthracite sizes. Of these the one most nearly approximating the pinhole grate air distribution showed a uniformly bright fire with comparatively few sparks blown up from the grate, whereas the other, which was more of the bar and air space type, showed the complete pattern of the grates in dull fire against a brighter background of the air spaces and showed a much larger amount of sparks blown off the grate.

No one questions the possibility of using undergrate blowers without ruining the boiler settings, particularly when ample stack draft is available. When it is known, however, that, as in the case to which the original comment applied, 40-ft. of the original 70-ft. stack had been lost, probably reducing the draft even under the most favorable conditions from 0.35 in. at the damper to 0.15 in., this being barely enough to overcome the friction of the passage of gases of combustion through the boiler, at rating with a fair fire, it is practically certain that with any attempt to force the boilers in an emergency, or with normal load and poor fires due to bad coal or some other circumstance beyond the control of the fireman, the volume of gases would be too great to be handled by the stack and furnace pressures with their resulting troubles would occur.

H. D. Fisher.

Most Worn Piston Rings Had Better Be Replaced Than Repaired

After a year's run, snap piston rings will often be found to have a loose fit. One remedy is to expand them by peening but this is not the easy job some would believe. I have done the job at different times with more or less success. A poor job of peening performed by an inexperienced man will leave the rings in a worse condition than before he started; he may even break them. If the piston is comparatively small, say 12-in. or so, it would be best to have a new set of rings on hand before attempting to expand the old ones by peening. The cost of a new set would probably not exceed $15.

If you decide to attempt to peen them have your helper hold the ring firmly on a solid bench using one hand at each side of the joint so as to prevent any jar which might cause the ring to crack. Start at the center opposite the joint and hammer halfway around to the joint with the peen end of the hammer, striking it every ½ in. Repeat this process with the other side, then test the ring in the cylinder from end to end. The joint should be open about $\frac{1}{16}$ in. in every position. A man with machine shop engine fitting experience will do a passable job in this way. Men who have never even seen the work done by an experienced worker will probably make a bad matter worse.

If, upon examination, rings are found to be loose and it is decided to order a new set, make a gage out of a piece of ¼-in. rod, pointed at each end to get the exact diameter of the cylinder. Should you get the gage slightly short when pointing it with a file, hammer it lightly at the center and this will lengthen it.

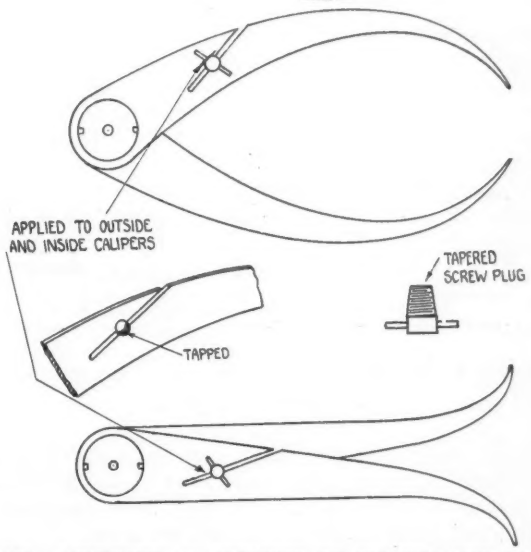
By sending this gage to a machine shop along with the exact width and thickness of the rings, the workmen can make you a new set without visiting the plant. Always note whether a new set of rings has the joint slightly open when set in the smallest diameter part of the engine cylinder. This is to provide for expansion.

Toronto, Ont. James E. Noble.

Refined Adjuster for Calipers

In setting calipers with the usual friction joint the practice is to tap lightly one leg of the tool against the machine to obtain a small movement required to close or open the legs a small amount in testing the work being calipered.

A most commendable improvement over this usual method is that of a mechanic in a local shop who has adopted a more refined means for tool adjustment, as shown in the accompanying sketch.



CLOSE ADJUSTMENT IS OBTAINED BY TURNING THE PLUG

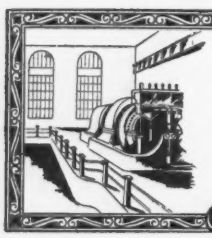
It will be understood that the screw used is tapered, which, when turned, opens the slot or allows it to close. This expansion causes only a minute movement of the caliper legs, consequently the tool can be closely adjusted.

Washington, D. C. G. A. Luers.

Loose Crankpin

In your issue of May 1 on page 502 there is an interesting article by Tom Jones on loose crankpins. Although Mr. Jones seems to be greatly surprised that the loose pin made no noise or did not run warm, the condition is not altogether unusual. I know of at least two cases where the crankpin was loose and it was not known or suspected until the engineer noticed the oiler running out of true. The engine was, of course, shut down immediately for inspection. Measurements were taken for a new pin and in the meantime a hole was drilled and tapped through the edge of the crank dish halfway through the pin, a bolt screwed in and the head riveted over. The engine ran in this condition until a new pin was made and the new engine could be conveniently shut down for a permanent repair.

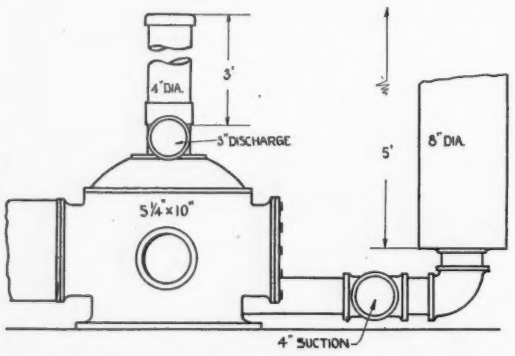
Hudson, N. Y. D. L. Simmons.



QUESTIONS AND ANSWERS

Air Chamber Capacity for Pump

I HAVE a duplex steam pump with air chambers arranged as outlined in the accompanying sketch. The discharge air chamber is made up out of 4-in. pipe with cap and coupling 3-ft. long and the air chamber on the suction line is 5-ft. long, made up out of 8-in. pipe. This pump is on elevator service and at certain speeds makes a clanking noise which is transferred through the pipe lines to the elevator pit and tanks which are some 60 ft. away. To overcome this noise I intend to do away with



ELEVATOR PUMP FITTED WITH AIR CHAMBERS ON SUCTION AND DISCHARGE LINES

the air chamber on the suction line and make up an air chamber for the discharge out of 10 or 12-in. pipe of such length as to give a volume of at least three times that of the water cylinders. Will this cure the noise?

CHARLES L. RIECKE.

Metering the Blowoff

WE HAVE found it desirable to measure in some way the blowoff water from our 8000 hp. of boilers. The problem has been put up to me but I find myself at a loss to know how it could best be accomplished. Actual weighing cannot be employed because of the evaporation losses. A flow meter might be installed but it seems to me that the maintenance on orifice plates or throats would be excessive on account of the scale in the water. Would it be possible to get a fairly accurate figure on the amount of blowoff by noting the fall of the water in the boiler gage glass, the glass being calibrated to show the quantity of water in the boiler at various heights? G. W. G.

Water Backs Burn Out

IN THE plant where I am employed we have eight horizontal water-tube boilers, all of them equipped with circulating water backs. They are 6-in. diameter where they are exposed in the furnace bridge wall. The connections to the boiler drum are 4 in. and 3 in. to the water leg.

In what direction does the water travel in an arrangement of this kind? Of what benefit is the water back?

Recently we have had trouble with one burning through where it is exposed to the fire. As a matter of fact this particular unit has been replaced three times in a month and we have as yet been unable to determine the cause of the failures.

What can the trouble be and how can it be remedied?

F. F. M.

Charging Ammonia System

MR. WHITE'S reply on page 569 of the May 15 issue, to Mr. Fagnan, on charging the ammonia system, brings up a question worthy of some mention. I also disagree with Mr. Fagnan's statement that the anhydrous ammonia could flow back into the drum from which it is being drawn. I have charged ammonia in several machines and have not yet experienced ammonia flowing back into the drum.

In most cases anhydrous ammonia is held in liquid form in the drum under a pressure of 170 lb. or more, while on the low pressure side of the system the pressure seldom exceeds 10 to 15 lb. It is better to recharge on this low side than elsewhere to insure all the ammonia leaving the drum. Not more than 10 to 15 lb. gas pressure should be left in the drum, as indicated by the gages on the low pressure side.

The usual procedure is to connect the pipe from the drum to the low pressure side with a 2-in. block under the rear end of the drum so that the ammonia will flow to the stop cock. Open the cock on the receiver first, then open the cock on the drum until frost appears on the connecting pipe. At the same time notice the pressure on the low pressure side of the system. It should not build up more than 5 lb. If it does throttle the stop cock on the drum more to keep the pressure down.

Heavy snapping, cracking noises in the connecting pipe and a rapid accumulation of frost shows that the ammonia is flowing too fast, even if the gage does not show much increase in pressure. It may require considerable time to put in a whole drum of ammonia.

When the drum is empty the frost will leave the connecting pipe and the pressure on the low side will drop to normal which would leave only 10 to 15 lb. pressure in the drum.

Empty and full drums are often mixed in storage and it is safe practice to weigh them before recharging. If an empty drum were connected by mistake to the low side with 10 to 20 lb. pressure on there would be a slight return flow to the drum until the pressure increased to that indicated by the gages on the low side. I would not charge directly to the cylinder if it were possible to avoid it, as there is considerable risk of freeze-back.

Mr. Fagnan says he does not believe in pumping down to a vacuum before recharging as it brings too much air into the system. It would seem that there is something wrong with his system. If air can leak in with a vacuum on the low side, then ammonia gas can leak out when there is a pressure of 15 lb. or more on the low side. If the machine should stop when the charge is almost completed and the pressure in the drum had been reduced to say 10 lb. the pressure would rise on the low side of the system and there would be a back flow into the drum. In such a case the gage would show an increase in pressure and the frost would leave the connecting pipe. This may be what Mr. Fagnan referred to, but it should not occur if proper care is used in recharging.

Cambridge, Mass. R. A. CULTRA.

Use of a Trap in a Vacuum Return Line

IN REPLY to the question by M. O. P. in the June 15 issue, "Would a trap in the return line help?" I would say that with a range of pressure from 5 to 25 lb. on the heating system, the pressure is too high for a vacuum system in which the radiators are equipped with thermostatic traps. Many of the thermostatic traps on the market have a diaphragm which contains a highly volatile liquid. When it is subjected to the temperatures of steam at these pressures the diaphragms are expanded to such an extent that they either bust or become distorted. These traps are designed for systems where exhaust steam is used for heating at low pressures, not exceeding 2 or 3 lb.

There is, however, a type of ball float trap on the market with which the radiators could be equipped, that are not affected by temperature and they would overcome the trouble.

I am assuming that the return lines in the system have not been graded to a common point, and that the distances are so great that it is necessary to use a vacuum pump to obtain adequate circulation. The method suggested of installing low pressure traps will not work if the traps which are intended to be installed are of the ordinary bucket type. The vacuum pump will pull the water out of the body of the trap, allowing the steam valve to open and pass steam through at all times. The idea will work if a vacuum float trap is used in place of the ordinary low pressure trap.

North Platte, Neb. A. M. CASBERG.

Priming and Foaming Defined

WHAT IS the difference between priming and foaming? How can one action be distinguished from the other? What can be done to allay the causes of each?

O. W. G.

A. Priming is an inherent characteristic of the phenomenon of boiling and cannot be entirely eliminated. Its violence may, however, be considerably reduced by proper proportion of the steam disengaging surface. As bubbles of steam are formed and rise to the surface of the water, they break through this surface with considerable velocity and in the act of disengaging from the surface, small quantities of water are carried along. The amount of water or spray thus given off is in direct proportion to the rate of boiling, consequently priming troubles increase as the rate of working of the boiler is increased.

By proper design the steam disengaging surface in a boiler may be made sufficiently large to permit of relatively low velocity of the steam as it emerges from the water. Large steam spaces over the boiler water surface tend to reduce the velocity of the steam in the drum and permits the entrained water to fall back onto the water surface. Judicious use of water baffles and dry pipes will do much to prevent entrained water being carried into the steam line.

Foaming, on the other hand, is due to the condition of the boiler water. The presence of oil, greases, vegetable elements or certain scale forming materials in the boiler water will cause a foam or froth to appear on the surface which impedes the disengagement of the steam and which is likely to be carried over into the steam line. Foaming can be eliminated by proper boiler feed water treatment and by the elimination of oil and grease from any exhaust that is used for feed water heating.

What Causes the Hook?

ON PAGE 618 of the June 1 issue, J. L. has a set of indicator cards for criticism. The first thing noticeable is that admission on the head end of the high pressure diagram is a trifle late and that the steam line on the crank end falls below the admission line which seems to indicate a tendency towards wire drawing. The point of cutoff is not equal, as shown by the inequality of the area of the two diagrams, more work being done by the crank end. If admission can be made to take place a little earlier on the head end, that may equalize the card without any farther adjustments.

On the low pressure cards, several things are not right. The humps are caused either by leakage past the piston or double admission, although this is not likely on a compound engine. The admission line on the head end leans in, denoting late admission, the same as on high pressure head end. Terminal pressure on both ends of low pressure is as high or higher than the compression, denoting late opening of the exhaust valves.

I would imagine that the engine pounds a little on the low pressure side, as in addition to the unbalanced condition of the cushion the cutoff is unequal. Also the full benefit of the condenser is not realized on account of the late opening of the exhaust valves, the pressure does not go down ahead of the piston until about one-half of the return stroke is completed. If it is a single eccentric engine the eccentric may have to be moved ahead a trifle. Opening the exhaust valves earlier, will increase the compression, but I believe that this engine, running at the speed it does will stand it all right without any trouble.

The speed is not so high but that it should be possible to change any or all valves with the radius rods connecting them to the wrist plate, while running, unless the rods are so situated that a wrench cannot be applied on them while running. I have changed every valve on a non-releasing Corliss running 204 r.p.m. without shutting down and in a case of emergency, when a dash pot rod broke, uncoupled the valve gear on one end of a 26 by 48-in., 80 r.p.m. Corliss engine without shutting down and ran on one end until the end of the shift when a new rod was ready.

Minneapolis, Minn. FRED S. RUTLEDGE.

EDITORIAL COMMENT

Power Problems to Be in the Torchlight Parade

It is rather significant that the platforms of both major political parties contain certain planks which deal with problems of interest to the power industry. These planks cover water power, the problems of fuel supply and statements of position with respect to government control.

Water power resources, according to the Republicans, should be developed only as needed and only after the public need has become a matter of public record, controlled with a scrupulous regard and ever vigilant safeguards against waste, speculation and monopoly.

In commenting on the federal water power act, the Republican platform states that the act establishes a national water power policy and that the way has thereby been opened for the greatest water power development in history under conditions which preserve initiative, yet protect public interest.

According to the platform the Democrats favor the suspension of the granting of federal water power licenses by the Federal Water Power Commission until Congress has received reports from the Commission with regard to applications for such licenses. It is also the belief of this party that the nation should retain title to its water power. Expeditious development of water power is favored.

Under the subject of waterways the Democratic platform favors liberal appropriations for prompt coordinate surveys to determine the possibilities of general navigation improvements and water power development on navigable streams and their tributaries, to secure reliable information as to the most economical navigation improvement, in combination with the most efficient and complete development of water power.

Muscle Shoals is touched on the Democratic platform, with the statement that prompt action should be demanded of congress for the operation of the plants to maximum capacity in the production, distribution and sale of commercial fertilizers to the farmers.

Both parties are out gunning for the coal industry, the Republicans stating that "the price and constant supply of this essential commodity are of vital interest to the public. The government has no constitutional power to regulate prices but can bring its influence to bear by the powerful instrument afforded by full publicity. When through industrial conflict its supply is threatened, the President should have authority to appoint a commission to act as mediators and as a medium for voluntary arbitration. In the event of a strike the control of distribution must be invoked to prevent profiteering."

Democratic viewpoints are expressed in the pledge to regulate by governmental agencies the anthracite coal industry and all other corporations controlling the necessaries of life where public welfare has been subordinated to private interests.

These planks of water power and on fuel control indicate an awakening of public interest in problems of this character. It shows that this awakening has proceeded to the point where votes may be gained or lost on the issues involved. Hence the significance.

Inland Navigation as a Factor in Turbo-Generator Design

With the steady increase in the size of our generating units has come the question, how big can we make them? What are the limits to which the increase in size can be carried? Are these limits of an electrical or mechanical nature, or are they governed by economic considerations? We have seen turbo-generators grow from 5000 kw. to 50,000 kw. and now we are talking about still larger units.

Manufacturers have stated that insofar as immediate increases in size are concerned the limits are imposed neither by electrical nor mechanical considerations but rather by transportation facilities. The widths and heights of tunnels and viaducts along railroad rights of way are vital factors in limiting the size of parts which may be transported through them.

In the recent installation of the 35,000 kw. frequency converter at Hell Gate Station in New York, it was found that the diameter and length of the rotors made it impossible to ship them by rail. The route of the New York State Barge Canal, however, was convenient both to the point of shipment and point of destination, so it was decided to ship the machine by barge.

It appears, therefore, that internal navigation is a factor in machine design, and in planning new machines, manufacturers may find it profitable to study the possibility of utilizing inland water ways and to urge their further development. Water offers a cheap, reliable means of transportation and its greater utilization would relieve the railroads of much congestion.

Economy and Plant Additions

Growth of the load of a power plant introduces many complex problems other than that of simply meeting the increased demand for power. These are of necessity the outgrowth of the increased demand; however, as each problem presents itself it becomes of paramount importance until it has been solved rationally and economically.

It is not a difficult matter to arrive at the immediate increase of demand. A more difficult problem is to determine upon how much additional equipment must be added to supply an anticipated demand which will come within the next few years. The economics of the situation plays an important part in the selection of the number, size and type of units selected and the housing facilities to be provided for the new units which will be installed now and which are to be installed in the future.

In many cases the old units are obsolete not only as to type but also as to steam pressure and temperature. It is

probable that only a part of the old equipment can be used as spare equipment. This increases materially the cost of the new plant, because new equipment must be added to take care of that portion of the load which was formerly carried by the units which must be dismantled for the sake of economy.

It has been found in a great many instances that the housing facilities for the older types of units were wasteful of floor space, not only because of the floor space actually occupied but also due to the lack of appreciation of the cost of unused floor space. In such instances it has been found that a large economy in the total cost of the new plant can be made by an arrangement of the new equipment such that it will occupy space in the old building.

One example of this type of economy can be found in this issue in an article which describes the development work which has taken place at the Stearns Light and Power Co. at Ludington, Mich. In that installation the old units were obsolete as to type, steam conditions and economy. This meant that the old units had to be superseded by those of greater economy and improved steam conditions. The fact that this plant had not owned a boiler house and equipment made the economic situation that much more severe because money had to be provided for a complete new boiler house.

By a careful study of the engine room layout it was found possible to scrap several old units and so provide floor space for the new generating equipment and to so locate it that it was favorably situated with respect to the new boiler house. This problem was solved without spending money for an addition to the engine room. It is a good example of what can be done to bring a plant up to date without burdening the overhead expense with unwarranted charges which must be carried throughout the life of the plant.

Planning of this kind often means that pride and the incentive to spend money uselessly must be cast aside and that plain and straight-forward thinking must be brought into play.

Off Duty

"—and do you know, we had a perfectly lovely time at the color concert last night. The music was delightful. 'Ryan's Symphony in Violet' was splendid and so was 'Luckiesh's Prelude in Orange-red.' Myrtle, who was with me, enjoyed 'Excerpts from the Infra-red,' but so much of it was invisible to me that I personally did not care for it."

Such may be the conversation after attending a color concert some time in the near future. Color concert, do we hear you exclaim? What is it? Well, perhaps we had better explain a bit.

Music, as we all know, consists of groups of sounds agreeably arranged and co-ordinated as to time and tone so as to please the senses through the mechanism of the ear. That is the purely mechanical definition of music, and while it is not complete and does not tell us why music gives us pleasure, it will suffice for the present. Understand, it consists of groups of sounds, not single tones. A single tone is not music. We might take a single tone, study its quality and determine its degree of acuteness or pitch, but it can never become music so long as it remains isolated. It must be associated with another tone to become music.

Sound, science teaches us, is a vibratory phenomenon in the air or other material substance, and is capable of affecting the senses through the mechanism of the ear.

Now, what is light? Light, science also tells us, is a vibratory phenomenon in an hypothetical medium known as the ether. A rather formidable definition for something so obvious, and, unless we possess a rather flexible imagination insofar as the ether is concerned, still leaves us very much in the dark. It is sufficient, however, to know that it is a form of vibration and that these vibrations are capable of affecting the senses by means of the eye.

Disregarding for the moment, all special considerations regarding wave length and frequency of vibration, it is apparent from the foregoing that there is a similarity between sound and light. Both are vibratory motions and both affect one of the senses. Both, too, are extremely necessary and the absence of either one would leave us seriously handicapped.

In addition to its obvious function of utility, sound, however, also contributes much to our enjoyment and pleasure when it takes the form of music. Music, therefore, is dual in its nature. It is spiritual as well as material, and in some mysterious way gives rise to different emotions. Its material side we apprehend through the sense of hearing; its spiritual side reaches us through fancy or imagination.

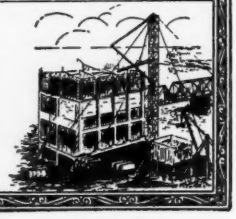
Very well, then, if it is true that both light and sound are similar as regards their nature and power of affecting the senses, the question has come up whether there is anything that possesses the same relation to light that music does to sound. In other words, can we have music which instead of being composed of groupings of sound waves, is composed of groupings of light waves or colors? Can we give pleasure to the senses by producing harmonious combinations of color?

While no evidence has ever been shown in support of any such theory, it is interesting to speculate upon the question. If there exists anything of such a nature, and experiments are under way to prove or disprove it, it is entirely possible that sometime during the near future we shall be able to attend a *color concert.*

Just what such an affair might be like, we leave to your imagination. Whether we shall be able to translate Liszt's Rhapsodies or Beethoven's symphonies into color, or whether "color music" will be of an entirely different nature from "sound music" is also a matter for you to speculate upon. Whether a spot-light solo will produce the same type of emotional disturbance that a violin or cello solo does, we do not venture to guess. Color may give rise to an entirely different type of emotional disturbance.

Imagine the consequences of such a discovery. The young lover, instead of serenading his "beloved" to the accompaniment of a guitar will probably shatter the moonlight glow with a battery of flood lights. If, at the concert, we are so unfortunate as to have seats in the back row, and cannot "see" the music distinctly, all we'll need is a pair of binoculars. If the music of the "color hurdy gurdy" on the street causes annoyance and distracts us from our work, we need only pull down the shade to shut out the din. If at dinner the orchestra interferes with our conversation, all we need do is to put on a pair of dark glasses. Indeed, the possibilities of the idea are limitless and space does not permit further speculation. In closing, however, a sad thought comes to us—what about the person who is color blind? He, it seems, is going to be plum' out o' luck.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Electrical Engineers Convene at Chicago

ANNUAL CONVENTION OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS MARKED BY PAPERS OF UNUSUAL INTEREST AND VARIED SOCIAL EVENTS

PAPERS OF VARIED and unusual interest, combined with a well balanced mixture of sport and social events, made the annual Convention of the American Institute of Electrical Engineers at the Edgewater Beach Hotel, Chicago, June 23rd to 27th, one that was enjoyed by all who attended it.

The only disappointing feature of the entire meeting was the absence, due to illness, of President Harris J. Ryan, whose presence at the meeting everyone had counted on. Professor Ryan, while not seriously ill, had been advised by his physician not to make the trip from California. His absence was regretted by all.

Because of the large number and wide range of subjects covered by the papers presented at the technical sessions, it will be impossible even to touch upon more than a few of them. Among the subjects treated were distribution, cables, automatic stations, reactors, communication, electrophysics, street lighting and electrical machinery.

The scope of the activities of the Institute throughout the past year is perhaps best illustrated by reviewing some of the facts set forth in the reports of the technical committees. These reports presented on Tuesday, June 24th, embraced a wide range of endeavor and their presentation could not but impress one of the importance of the electrical engineer in modern civilization. President Ryan, in a telegram to the Convention, struck the right note when he stated that one of the greatest triumphs of the Institute was the discovery during recent years that all things in nature have an electrical foundation.

FIVE MILLION KV.A. GENERATING CAPACITY INSTALLED DURING YEAR

According to the report of the Power Stations Committee, the most impressive feature of the year's power station work was the unusually large building activity of both steam and hydraulic plants, amounting to approximately five million kv.a. of generating capacity and a continued tendency toward larger stations and larger units. Hardly in any other year than during 1923, have so many schemes been introduced to increase the steam power plant efficiency. The insecure and varying grades and qualities of coal have given fuel oil and pulverized coal a very strong impetus. It appears that although for some time pulverized coal had been used, no uniform practice has developed. The mode of firing especially appears to lack satisfactory solution. The size of boilers in furnaces has rapidly increased to considerable dimensions and it has been proposed to build a single boiler to supply a 30,000 kw. turbine generator unit. Such a boiler would have a heating surface larger than the biggest boiler now used, by about third.

The tendency in large hydraulic electric stations consisting of two or more vertical units seems to be in favor of a single floor station, with the main floor at approximately the elevation of the top side of the turbine casing, or about the center line of the main turbine steady bearing.

Outstanding as to size, are the 70,000 hp. hydraulic turbines for the Niagara Falls Power Company, operating under the head of 213½ ft. at a speed of 107 r.p.m. and connected to a 65,000 kv.a., 3 phase, 25 cycle, 12,000 v. generator.

CIRCUIT BREAKER PRACTICE

With regard to switches and oil circuit breakers the report stated that manufacturers of oil circuit breakers are making herculean efforts to keep pace with the requirements of the industry, but to date no breaker with an interrupting capacity greater than 1,500,000 kv.a. has been installed.

It is believed that oil circuit breakers of very much greater interrupting capacity than have been manufactured, can be successfully made, provided the need is great enough to justify the cause.

Gang-operated disconnecting switches interlocked with the oil circuit breakers are to a great extent replacing single pole switches operated by a switch hook. In one of the newest large central stations, practically no disconnecting switches are used for disconnecting the oil circuit breakers from the bus or line. The disconnection of the breakers is accomplished by lowering them below their normal position, thus breaking the connections and isolating the breakers.

The isolated phase arrangement of switching equipment is becoming standard and all of the larger metropolitan companies have adopted this system. This type of construction has eliminated in some instances the conventional bus structure.

In the development of lightning arresters, the so-called lighting generator of Steinmetz has revolutionized the testing of arresters and by means of it, their performance can be closely predicted.

Another interesting report presented at the session on Tuesday, June 24th, was that of the Telegraphy and Telephony Committee. This report covered telephone equip-

ment, telephone transmission, outside plant practices, telegraphy, submarine telegraphy, radio, military signaling, telephone, telegraph and radio terminology, carrier current telephony, supervising signaling systems, audiometers and the transmission of pictures over telephone wires.

The last subject mentioned was of particular interest to the members attending the Convention as they were given the privilege of inspecting the equipment used for transmitting the pictures of the Democratic Convention from New York to Chicago. This was arranged through the courtesy of the American Telephone and Telegraph Company. Each member was also presented with two photographs, one of President Ryan and the other of President Elect Farley Osgood, which had been transmitted over the telephone line from Chicago to New York.

Transoceanic Telephony Soon a Possibility

The Telegraph and Telephone Committee also reported that tests of radio transmission from America to Europe have been carried out at practically weekly intervals throughout the year, and this data, together with the data which will be made possible by two-way tests, will determine the practicability of a United States to London Trans-Oceanic telephone service.

Under favorable weather conditions next winter, it is the expectation that telephone subscribers in the United States and London can be connected so that they can talk together as over an ordinary long distance telephone circuit.

The Committee on lighting and illumination reported a number of new developments. In the manufacture of incandescent lamps, machinery has been further improved and more widely applied. Although tipless lamps have been made for some time, the process has now progressed to a point where practically all of the more common types and sizes of tungsten lamps are being made without tips.

Considerable progress was reported in the development of traffic signals, both in those used for control of traffic and those which simply warn drivers of busy intersections.

Another development which has attracted wide attention during the past year was the employment of colors in more or less indefinite form without musical accompaniment. For a number of years, considerable interest has been shown regarding the question as to whether or not there is something related to light as music is related to sound. These experiments in the projection of colors are along lines which may satisfy this question.

Among the papers which brought forth the most animated discussions were those dealing with current limiting reactors, and the paper describing a new type of single phase motor, presented by S. R. Bergman. The latter paper dealt with the development of a constant speed a.c. motor for application to single phase current. When running at normal load it has a very high power factor in the neighborhood of 95 per cent. Under certain conditions of load, the machine may even have a leading power factor. This paper was discussed in detail by a number of members, particularly by Mr. Fynn, one of the co-inventors of the Fynn-Weichsel motor. Mr. Fynn whose written discussion was presented by Paul M. Lincoln took the stand that there was nothing radically new about Mr. Bergman's motor and that he had practically developed the same machine as early as 1907. Professor Karapetoff called attention to the fact that a number of attempts have been made to develop motors which would have the high starting torque characteristics of the series wound motor and the simplicity of the induction motor. Mr. Bergman's motor, he pointed out, was a machine of this type. Mr. Bergman's motor he stated, however, was not the ultimate that could be expected along these lines, but it nevertheless was a step in advance and its use would undoubtedly lead to further development of this type of motor.

The Inertaire Transformer

The paper entitled "The Inertaire Transformer" presented by W. M. Dann and D. R. Kellogg was another paper that was received with interest and invoked much discussion. In the Inertaire Transformer, oxidation of oil in transformers is prevented by the introduction of nitrogen into the case above the surface of the oil, thus eliminating all possibility of oxidation. The nitrogen is obtained from the outside air by a breathing process in which the breathed air passes into the transformer through chemicals which absorb the 21 parts oxygen leaving only the 79 parts of nitrogen to pass into the case. In discussing this paper, D. R. Dalzell of Pittsfield, Mass, stated that he believed that a better method of preventing oxidation of the oil due to contact with air, was to fill the transformer case entirely and to provide a short standpipe above the top of the case to take care of pressure variations. This method is used by the General Electric Co. in connection with the use of their oil conservators. If nitrogen is to be used, Mr. Dalzell stated that he believed it better to supply this gas from an auxiliary tank rather than by means of a breathing apparatus.

In discussing the use of current limiting reactors the question was brought up as to whether the reactor should be first or last to fail in case of trouble. Expressing it in other words, should the reactor be the weakest or the strongest link in the electric circuit? Opinion was divided although it seemed the majority of those who discussed the subject were of the opinion that the reactor should be the strongest part of the circuit. N. L. Pollard stated that in his estimation the reactor should be the last to fail. Reactors are provided for protection, and if this means of protection is subject to failure with the first severe wave of disturbance the entire advantage of this protection will be lost. If the reactor fails, there will be an excessive strain imposed on the oil circuit breakers.

The fact that the current limiting reactor has not found favor with a larger number of electrical engineers was attributed to the high interest charges on the cost of installation. The cost of the reactor itself is not of such great importance, but the additional cost of buildings to house them, the cost of constructing cells, etc., all make for high interest charges and as a result the general attitude of the engineer has been against reactors.

Inspection Trips

Among the inspection trips which were arranged for the members of the Institute, the two most important were those to the New Waukegan Generating Station of the Public Service Co. of Northern Illinois, and to the Calumet Station of the Commonwealth Edison Co.

The latter trip was particularly enjoyable as it was made by boat from Lincoln Park. The trip to the Wauke-

gan Station was made by motor busses and included a visit to one of the automatic substations of the Chicago Rapid Transit Co.

Social and Sporting Events

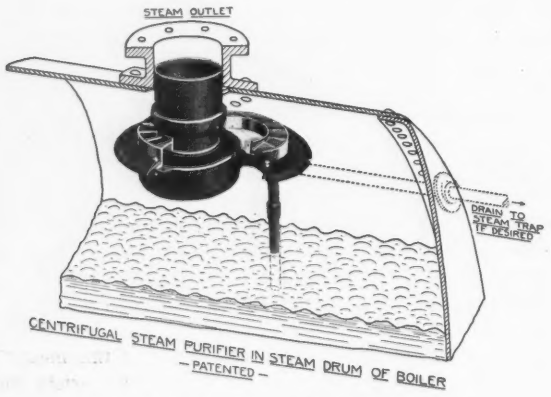
The convention was not lacking insofar as social and sporting events were concerned. The Convention Committee had made every possible arrangement which would contribute to the enjoyment of the members and guests and the social activities were kept at a high pitch during the entire week. For those who like golf there were plenty of opportunities for playing. Tennis also came in for its share of the program.

On Wednesday evening a particularly enjoyable event was the musicale given by Professor Karapetoff and Madame Louise Bernet. Professor Karapetoff gave interpretations of classical piano selections which illustrated to a high degree the wonderful versatility of the Cornell professor's abilities.

The convention came to a close on Friday afternoon with the playing of the annual baseball game.

Steam Purifier of Novel Design

ALL engineers who have had experience with wet steam will recognize the vital necessity of delivering clean, dry steam from boilers. High ratings on both boiler and superheater make necessary the prevention not only of



NEW HAGAN CENTRIFUGAL SEPARATOR

boiler scale and corrosion, but also of the moisture in steam which frequently accompanies adequate chemical water treatment.

Appreciating the need for a steam purifier which could be easily and quickly installed in a boiler drum, would deliver dry steam under all conditions with practically no maintenance and cleaning charges, and be relatively inexpensive, the Hagan Corporation of Pittsburgh has placed on the market the apparatus illustrated. It was developed during a cooperative research between this company and the United States Bureau of Mines, on the mechanism and prevention of scale formation and boiler corrosion.

As will be seen from the figure, the purifier depends on the principle of centrifugal separation. By using customary steam line velocities through the separating elements, compactness, ruggedness and freedom from clogging may be obtained. The use of high velocity separation also makes it possible so to design the steam inlet and water outlet that the pressure drop from drum to steam nozzle will always be much less than the centrifugal pressure on the water outlet. This means that under all usual conditions, the water discharge may be made directly into the drum through an open pipe, instead of through the shell, as is shown in the illustration. Even should the pressure drop rise to an excessive figure, say to 3 lb. or over 6 ft. of water, the centrifugal force existing in the bowl would immediately discharge any water against the higher pressure.

The height of the steam inlet above the water level is made such, and the inlet so protected by the apron that no large amount of water can gain access at any time. The turbine blading is designed to give only fractional pressure drops, and is arranged to prevent short circuiting of water to the steam outlet. It is impossible for moisture to adhere to the inside surfaces of the separator and be carried along to the steam outlet.

This device is made in several sizes for use with boilers having different sizes of steam outlets and operating at various average ratings. All sizes are assembled in a manner permitting their easy introduction through a standard 10 by 13 in. manhole.

National District Heating Association Holds Convention

AT THE FIFTEENTH ANNUAL convention of the National District Heating Association, held at the Hotel Commodore, New York City, on June 10-12, there were brought out a number of reports and papers of direct interest to power plant men. The second of the six business sessions was addressed by Dean Dexter S. Kimball of Sibley College, Cornell University, on the subject "Industrial Democracy," and on the following afternoon Edwin B. Ricketts of the New York Edison Company spoke with accustomed vitality about "The Operation of Steam Boiler Plants."

General economic problems involved in district heating were covered by the report of the Operating Statistics Committee, embodying the results of a questionnaire sent to heating companies throughout the country. The following are some of the figures derived from the returns from 27 companies furnishing steam heat:

Pressures at customers' service valves vary from 0.5 lb. to 150 lb., 9 companies supplying all or part of their steam at over 20 lb. pressure.

Steam sold, average, per company, 322,000,000 lb., per customer, 1,010,000 lb.

Loss between boiler header and customer's meter, in per cent of gross, average (25 companies), 19.6 per cent.

Steam sold per lb. fuel burned: Coal, average (13 companies), 6.13 lb.; oil, average (2 companies), 7.40 lb.

Annual load factor, steam sold basis: Average (19 companies), 23.2 per cent.

Cost of fuel delivered in plant bunker: Coal, per ton, average (14 companies), $5.24; oil, per bbl., average (3 companies), $1.33; hogged fuel, per unit of 4,000 lb., average (2 companies), $1.24.

Plant labor: Average per man per hr. (13 companies), $0.595.

Heating requirements: Lb. steam per sq. ft. of radiation per year, average (22 companies), 498 lb.

Mean temperature, heating season, average (22 companies), 42.8 deg. F.

Income per 1000 lb. of steam, average (25 companies), $0.867.

Theoretical cost of fuel and efficiency, on steam sold basis, using average results from companies answering questionnaire:

	Coal	Oil	Hogged Fuel
Unit of fuel	Ton	Bbl.	Unit
Weight of unit, lbs	2000	336	4000
Steam sold per unit of fuel, lbs.	12,400	2440	8533
Cost of fuel per unit	$5.24	$1.33	$1.24
Cost per 1000 lb. steam (fuel only)	$0.423	$0.545	$0.145
Evaporation per lb. fuel	6.2	7.25	2.133
Average B.t.u., per lb	12,100	18,515	4435
Efficiency (factor of evaporation 1.1)	54.8%	42.0%	51.5%

A paper submitted by the Distribution Committee dealt with determination of transmission losses for a certain installation, the temperatures existing around the pipe being measured by means of thermocouples placed at various distances from it. Theoretical line loss was computed as 102 B.t.u. per hr. per linear foot for wet soil and 72.5 B.t.u. per hr. per linear foot for dry soil, and all practical results obtained with conditions stable were found to fall within these limits, for the installation on which the tests were conducted.

Recording of pressures from remote points was another subject covered in the report of this committee. The system in use by the Detroit Edison Company was described. The gage unit consists of a recorder, a transformer and a transmitter. The recorder and transmitter are equipped with balanced solenoids swinging in a vertical plane over iron cores. In the transmitter, these are actuated by a helical pressure spring; while in the recorder, the solenoids are connected to a pen arm and are so connected and balanced as to be free to take any angular position corresponding to that of the solenoids in the transmitter. Connection between recorders and transmitters is by means of six-wire underground cable, three wires being employed for the gage unit itself, two for telephone connection and one as a spare. Twenty-five of these long distance units are installed on this system. Constant supervision is provided, and the results in operation have proved satisfactory.

Treatment of water to render the steam generated from it non-corrosive was the problem considered in the report of the Committee on Corrosion. A theoretical discussion of the electrochemical theory of corrosion was presented, with the following conclusions:

a. That corrosion is purely an electrochemical phenomenon due to the fundamental nature of water itself, but aided by even a very minute acidity.

b. That corrosion is promoted and made progressive and continuous by the action of dissolved oxygen in water, the gas acting as a depolarizer and thereby carrying on the activity of the corrosion process.

c. In domestic water, dissolved oxygen is the only depolarizer or *activator* present, hence the term *deactivator* may be applied to describe the apparatus used to remove dissolved oxygen from water.

Corrosion in boiler plants and distribution systems was then considered. In case of the former, the problem may be met by mechanical deaeration, in which the gases are removed by a boiling process, or by deactivation, in which a large metallic surface is provided for the water to act upon before reaching boilers and piping. In the case of consumers' heating systems a more complicated problem is met, and no definite conclusions have been reached. Some research work in this field was outlined, and tentative conclusions as follows were presented:

1. Oxygen in the water or steam is an important factor and perhaps the dominating factor in corrosion in central heating work. Any intelligent study of a corrosion problem must take this into account.

2. The oxygen content of the steam leaving the central heating plant should be kept below the danger point and periodical records of the oxygen content should be kept.

3. Oxygen can be absorbed by the condensation in some types of heating systems and the condensate at the discharge end thus rendered more active than that at the supply end.

4. Treatment of the water in the central heating plant and removal of its oxygen does not necessarily guard against all corrosion of the consumer's system.

A paper on "Some Aspects of the Feedwater Problem in Central Station Heating Plants," by M. Hecht of the Duquesne Light Company and C. H. Fellows of the Detroit Edison Company, described chemical studies of the feed water and steam cycles in a 1543 hp. Connelly type, Class "Z" Boiler, with purifiers for conditioning. Bled steam from the purifiers is used to run a house turbine and the exhaust from this turbine is employed for feed water heating. Samples of boiler water and steam were taken at numerous points in the system and the resulting analyses provided data which were useful in determining the exact conditions for the installation in question and in indicating the procedure which should be followed to avoid corrosion in the heating lines.

Winners of Smooth-On Prize Contest

THE EARLY part of this year the Smooth-On Mfg. Co. of Jersey City, New Jersey, announced a prize contest for the best story, based on actual experience, showing the use and application of Smooth-On. This contest has now been closed and the following awards are announced:

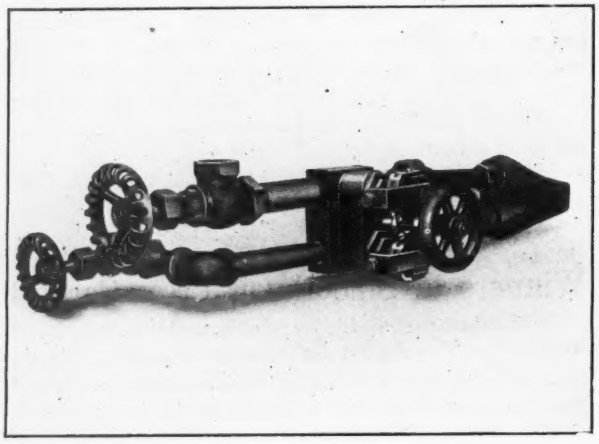
First prize, $100.00, D. A. Greminger, Gila Bend, Ariz.; second prize, $75.00, R. A. Skeldon, Toledo, O.; third prize, $50.00, J. T. Rushton, Nashville, Tenn.; fourth prize, $25.00, Verne B. Pope, Grand Rapids, Mich.; ten prizes of $10.00 each, Geo. T. Baker, Paulsboro, N. J.; John J. Doyle, Astoria, N. Y.; W. J. Edens, Commerce, Okla.; J. F. Girton, St. Paul, Minn.; W. J. Lapworth, Pittsburg, Kan.; John W. Lees, Plainfield, Conn.; Fred S. Rutledge, Minneapolis, Minn.; C. B. Thorne, Wooster, O.; Leeds C. White, Bay City, Mich., and Arthur U. Wolfe, Morgantown, W. Va.

Honorable mention was also awarded to each of the following: S. S. Adcock, Enterprise, Ala.; Ernest A. Biefeld, Watertown, Wisc.; Leroy Blake, Worcester, Mass.;

G. J. Bowles, Buffalo, N. Y.; Geo. Buth, Belleville, Ill.; H. T. Crabtree, Denver, Colo.; Edw. V. Darcy, Fall River, Mass.; Ernest W. Davis, Chicago, Ill.; Eugene F. Delery, New Orleans, La.; A. J. Dunn, Jackson, Miss.; Wm. A. Eckelcamp, Washington, Mo.; D. L. Fagnan, New York; John J. Flynn, Tenafly, N. J.; J. L. Hall, Anderson, Ill.; J. E. Hauser, Graford, Tex.; Geo. C. Hise, Los Angeles, Calif.; J. Hoffman, Seattle, Wash.; Martin R. Hunsucker, Clinton, N. C.; Augustus Johnson, Webster, Mass.; Chas. A. Johnson, Casselton, N. D.; W. T. Kenner, Washington, D. C.; C. E. Kling, Philadelphia, Pa.; G. D. Klopf, Redondo Beach, Calif.; Wm. D. Labadie, Chicago, Ill.; S. K. Lingerell, Urbana, O.; M'Kean Maffitt, Wilmington, N. C.; Geo. F. McCowbrey, Jersey City, N. J.; Michael J. Pecora, Philadelphia, Pa.; Robert Philipp, Washington, D. C.; E. R. Rivers, Decatur, Ga.; Geo. Saffer, Paducah, Ky.; W. F. Schaphorst, Newark, N. J.; Albert Schmiedel, Maspeth, N. Y.; G. H. Smith, Hoytville, O.; J. Napoleon Sorel, Providence, R. I.; Wm. C. Spooner, Regina, Canada; Frank Spurrier, Kingman, Kan.; Kenneth W. Sutherland, Dobbs Ferry, N. Y.; L. C. Topping, Fargo, N. D.; E. C. Trevorrow, Sterling, Colo.; Wm. S. Trofatter, Boston, Mass.; H. L. Weber, Louisville, Ky., and Harry W. Whetsel, Goshen, Ind.

One Valve Controls Oil Fuel and Atomizing Agent

IN THE Twin-Con valve, designed for simultaneous control of oil and the atomizing agent to oil burners by a single wheel, the discharge side has two square ports, the smaller for oil, the larger for the atomizing agent,



ARRANGEMENT OF TWIN-CON VALVE

which may be steam or compressed air, and which is to be under 5 to 10 lb. greater pressure than the oil.

For each port is provided a rotating valve, both valves being operated by the one control wheel and adjustment of the ratio of oil to atomizing agent being made by lock pins between the valves and the wheel. This adjustment can be made with the burner in operation until the best operating ratio is obtained. After that the ratio is maintained for all loads, the flame being varied to meet load conditions by turning the control wheel.

As shown in the illustration, the Twin-Con valve is installed between the main control valves and the burner.

Two vertical, parallel chambers are provided, one for oil and one for the atomizing agent, the valves operating in these chambers, with the stems, packed by high-pressure twisted graphite packing, extending through the top of the valve body to a connecting cross bar.

After reaming pipe connections and cleaning out all dirt, the Twin-Con valve is attached and blown out on both sides with the atomizing agent, the main oil control valve being closed and both valves of the Twin-Con wide open. The atomizing agent is next shut off from the oil side; the main oil valve is then cracked and the burner lighted by a torch. Adjustment is then made by changing the locking pin on the atomizing valve to reduce the supply of steam or air until good combustion is obtained.

Finally, the main oil valve is opened wide and the flame regulated by the Twin-Con control wheel.

This device is made by the Mechanical Specialty Sales Co., Brooklyn, N. Y., and is sold by John Foerst & Sons, of Bayonne, N. J.

General Electric Co. Arranges Conference of College Professors

THE GENERAL ELECTRIC COMPANY, in accordance with its policy of cooperating with educational institutions throughout the country, is arranging for a conference of college professors to be held at Schenectady from July 7 to August 9. It is expected, by means of this conference, that each visiting professor will be given an opportunity further to acquaint himself with subjects in which he is particularly interested.

It is the plan to have each individual spend the greater part of his time in the department whose work most closely coincides with his interests. Twice a week visits of inspection will be made throughout the plant, followed by round-table conferences with the engineers. Evening get-togethers will also be held of a more or less informal nature. A one-day trip to the Pittsfield plant is also planned for the purpose of studying the principles of transformer manufacture.

Among the professors who have made plans to take advantage of this opportunity are: S. R. Pritchard, Virginia Polytechnic Institute; S. R. Rhodes, Clemson; C. C. Yates, Texas A. & M.; E. B. Staveley, Penn State; J. H. Johnson, U. of Idaho; J. L. Beaver, Lehigh; F. E. Johnson, University of Kansas; G. C. Shaad, U. of Kansas; William Anderson, Rhode Island State College; M. M. Corey, Michigan Agricultural College; M. S. Coover, U. of Colorado; A. E. Watson, Brown; M. King, Lafayette; W. K. Rhodes, Bucknell; F. A. Fish, Iowa State College; William Esty, Lehigh; S. L. Simmering, U. of Colorado; L. J. Hodgins, U. of Maryland; J. Cameron, U. of Michigan, and E. H. Waldo, U. of Illinois.

A few professors, in addition to the conference, expect to spend the summer months at the Schenectady plant. Professor Vladimir Karapetoff, of Cornell University, and Professor J. M. Bryant, of the University of Texas, will be associated with R. E. Doherty, consulting engineer of the General Electric Company. R. F. Penman and J. H. Skeen, instructors in the department of electrical engineering at Cornell, will be located in the central station department. It is possible that there will be others included in this plan.

News Notes

SALE OF THE PLANT, equipment and good will of the Norwalk Iron Works Company of Norwalk, to Charles B. Stanley, a Cleveland banker, was confirmed by Judge Edwin S. Thomas of the United States District Court, in Norwalk, recently. The purchaser is a member of the Cleveland banking firm of Stanley and Bissell. His purchase was in the interest of bondholders, whose petition to foreclose a mortgage on the Norwalk properties forced the company into bankruptcy last December. Immediately following the purchase by Mr. Bissell he transferred the properties to the Norwalk Company, a new corporation which will operate the plant in the production of its familiar products, which includes compression machinery of all kinds.

Directors of the new corporation are Charles B. Stanley, Howard N. Bissell and Geo. F. Griffith of Cleveland; F. R. Hickman and E. H. Havens of Bridgeport, and R. C. Witmer and T. H. Hermanson of Norwalk. These directors, at a meeting following the sale, organized with Mr. Havens as president; Mr. Hickman, vice president and treasurer; R. C. Witmer, secretary, and T. H. Hermanson, works manager.

DE LAVAL STEAM TURBINE COMPANY announces the formation of a pacific coast sales organization covering the states of California, Oregon and Washington and parts of the adjoining states under the direction of William Pullen, with offices in Los Angeles, San Francisco and Seattle. The Los Angeles district office, 312 Union Oil Building, 617 West Seventh Street, is in charge of Ivan E. Goodner. The San Francisco district office, 531 Rialto Building, Mission and New Montgomery Streets, is in charge of Mr. Pullen, assisted by Eck Baughn and Chas. P. Markley. The Northwestern district office at Seattle, Wash., 1306-7 L. C. Smith Building, is in charge of James Q. Osborne, assisted by F. A. Hurlbut. These men are all well qualified to give reliable information and competent service in connection with the company's products.

A. J. JUPP, vice president Lunkenheimer Co., Cincinnati, left last week for London, England, to attend the world power conference which convenes June 30. He will represent the valve and pipe-fittings industry of the United States at the conference, which is to consider how the industrial and scientific resources of power may be adjusted nationally and internationally by a study of the potential resources of each country.

J. C. MERWIN, works manager, of the Chain Belt Company, Milwaukee, was elected second vice president at the annual meeting of the company, held in Milwaukee this month. Other new officers elected were: Brinton Welser as secretary and C. E. Stone as assistant secretary. Officers re-elected were C. R. Messinger, president; Clifford F. Messinger, first vice president; C. L. Pfeifer, treasurer.

MCCLAVE-BROOKS CO., Scranton, Pa., announces the appointment of G. Marshall Everson as district sales manager of the Pittsburgh District, with headquarters at 1623 Oliver Bldg., Pittsburgh, Pa. A new branch office is also being opened at Indianapolis, Ind., under the direction of Harlan W. Bird, 718 E. 27th St., Indianapolis, Ind. This new Indianapolis branch will function directly under the Chicago District Headquarters. The Adkins, Young and Allen Co. of Chicago will represent the company in the southern section of the State of Wisconsin. T. A. Coffin, formerly of the Heine Boiler Co., Phoenixville, Pa., has been appointed district sales engineer of the New England District, with headquarters at 200 Devonshire St., Boston, Mass.

DEARBORN CHEMICAL CO. announces the removal of its general offices in Chicago to 310 So. Michigan Avenue.

THE ROBERT JUNE ENGINEERING MANAGEMENT Corporation of Detroit, which handles industrial advertising, sales development and engineering management, is moving from its present address at 8938 Linwood Ave., to 8835 Linwood Ave.

THE AUTHORIZED capital stock of the Westinghouse Electric and Manufacturing Company was increased from $125,000,000 par value to $200,000,000 par value at a meeting of the stockholders held June 11 in the main office of the company at East Pittsburgh, Pa.

WEBSTER TALLMADGE, engineering specialist, has removed his offices from 50 Church St., New York, to the new Westinghouse Bldg., 150 Broadway, New York, where he will conduct an extensive business in engineering of steam power installations and high efficiency heating systems.

WILLIAM T. RUETE, inventor and authority on interior conduit, died June 7th in New York City. At the time of his death he was consulting engineer of the conduit and wire division of the General Electric Co. Mr. Ruete was identified with E. T. Greenfield in every stage of interior conduit development.

L. O. WILLIAMS, age 62, chief engineer of the Jacksonville, Ill., division of the Illinois Light & Power Corp., died suddenly on Sunday, June 8th. His death was caused by a stroke.

Mr. Williams had served in this capacity here for 7 yr., being located at Peoria, Ill., with the same company for 24 yr.

Books and Catalogs

PULVERIZED AND COLLOIDAL FUEL, by J. T. Dunn; 197 pages, size 7¼ by 9¾ in., cloth, New York, 1924, price $6.00 net.

The first section of this book, devoted to pulverized fuel, treats the subject largely from the point of view of the combustion engineer. A large part consists of descriptions of actual pulverized coal plants, involving engineering details of the various items that go to make up a complete plant, such as crushers, driers, pulverizers, transport systems, feeding devices and furnace construction. The process of combustion is, of course, primarily a chemical one and it is perhaps in this phase of the subject that the combustion engineer is mostly interested. To cover this phase of the subject the author has included a considerable amount of information on the underlying chemical principles and an account of the advantages and disadvantages of the use of pulverized fuel for various purposes.

The section on colloidal fuels is an account of what has been done in this field. It points out the advantages to be gained and discusses methods by means of which coal may be satisfactorily mixed with fuel oil to form a colloidal solution.

BELIEVING THAT enough thermo-electric pyrometers are in use to warrant a special publication on their installation and care, The Brown Instrument Co., of Philadelphia, has recently published a 72-page book covering this subject. It is entitled "Instructions for Installation and Care of Thermo-Electric Pyrometers." Protecting tubes for thermocouples, various methods of wiring indicators and recorders, methods of eliminating cold junction errors, methods of installing couples, checking thermocouples, wiring, or the accuracy of the instruments are subjects which are gone into from the practical and theoretical angles. Such other subjects as open and conduit wiring, mounting the instruments, locating defects in the thermo-electric circuit by various means, and many other points, are covered. This book also contains temperature millivolt equivalents for the thermocouples and conversion of Fahrenheit and Centigrade Scales. It is free to users of pyrometers.

THE THIRD EDITION of "Handy Wiring Tables and Illuminating Data," has been recently revised and published by the Westinghouse Electric and Manufacturing Company. This 52-page booklet contains detailed directions for accurately laying out the wiring for an industrial or commercial lighting system. An interesting feature of the publication is a table of the present standards of desirable illumination for various classes of service, giving the range of foot-candles most desirable for illumination in practically every branch of industry where artificial light is used. Practical electrical definitions at the beginning of the book are followed by wiring formulae and tables, together with illumination classifications. A complete table of foot-candle values for lamps of different wattage in areas of different size is included. Various types of commercial luminaries manufactured by the Westinghouse Company are described and pictured.

THE SUPERHEATER COMPANY of New York and Chicago have just issued a second edition of its instruction book coverng installation, operation and maintenance for Model 496 superheated steam pyrometers. While the book is intended primarily to give instructions covering the application of the pyrometer to superheater locomotives, there are also given special instructions relating to marine and stationary industrial plants. A pyrometer test set is described and inspection of the pyrometer and tests of various parts with and without the test set are given. An added feature of this description of the book is the order list covering pyrometer parts in the back of the book.

BULLETIN No. 31, just issued by the Ridgway Dynamo and Engine Co. of Ridgway, Pa., is devoted to a description of their turbo-generator sets, and supersedes Bulletin No. 28. The bulletin is well illustrated with photographs and line drawings describing the various features of high pressure, low pressure and extraction type turbines. Considerable space is devoted to the turbine governor. These turbines are built in sizes from 300 to 5000 kw.

"HYTEMPITE IN THE POWER PLANT" is the title of a new bulletin issued by the Quigley Furnace Specialties Co. of New York City. This bulletin illustrates and describes some of the many successful applications of Hytempite in refractory construction and maintenance. It tells why thin joints are recognized as correct practice in fire brick masonry and why a cemented joint is far superior to fire clay. The use of crushed old fire brick for patching and rebuilding furnace walls, making monolithic baffles and special tile, is described and illustrated in considerable detail, giving tables of the correct mixtures together with methods of application. Special stress is laid on mixing of the ingredients and application, on which depends the successful use of granular refractories.

THE UNIVERSAL COAL Spreader Co. of Chicago has issued an 8-page bulletin describing their coal spreader. This is a device which distributes coal evenly into the hoppers of automatic stokers. It is adaptable to any type of stoker served from overhead bunkers.

JAS A. MARTOCELLO & Co. of Philadelphia has just issued Catalog No. 50 describing Martocello Raw Water Ice Making Systems and supplies.

THE PAGE WATER TUBE Boiler Company of Chicago has just published a 12-page catalog describing the Page Cross-Drum Water Tube Boiler. A number of pages are devoted to the reproduction of setting drawings.

PAWLING AND HARNISCHFEGER Co. of Milwaukee, Wis., have issued Bulletin 600-X describing their model 200 excavator and crane. This is a crawling crane and was designed for the purpose of providing a simplified high-grade earth-moving machine at low cost.

BULLETIN No. 2055, just issued by Crouse-Hinds Co. of Syracuse, N. Y., describes their line of Arktite Circuit breaking plugs and receptacles. These plugs and receptacles embody an entirely new principle in plug and receptacle construction and are designed to meet the demand for circuit breaking plugs and receptacles in capacities heretofore considered impractical. As the name implies the arc formed by pulling the plug is so completely confined in a chamber of insulating material that it is impossible to form a short circuit or ground. The air and gases confined in the chamber expand rapidly and smother the arc.

GRAVER CORPORATION, East Chicago, Indiana, has issued in booklet form the report of an investigation made by the A. C. Nielsen Co., of the Graver Hot Process Softener in use by the Independent Pneumatic Tool Co., Aurora, Ill. This report shows that the Hot Process Softener installed by this concern is saving them annually $6,810.25 in coal and labor. A tabulated cost and saving statement is included.

IN A 36-PAGE, two-color publication, entitled "Westinghouse Fittings for Pipe Structures," the Westinghouse Electric and Manufacturing Co. has recently announced a new and complete line of interchangeable pipe fittings for structural work. The publication, which is known as Circular 1676, describes these fittings and gives their application to such work as the erection of outdoor substations, switching equipment, switchboard frames, racks, railings, fences, etc.

TRACY STEAM PURIFIERS is the title of a 36 page catalog issued by the Andrews Bradshaw Co. of Pittsburgh, Pa. Reasons are presented as to why the Tracy steam purifier was developed and the discussion then shows just what this type of steam purifier will do. About 15 pages are devoted to a consideration of troubles that result from wet, dirty steam.